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THE BRITISH JOURNAL OF METALS

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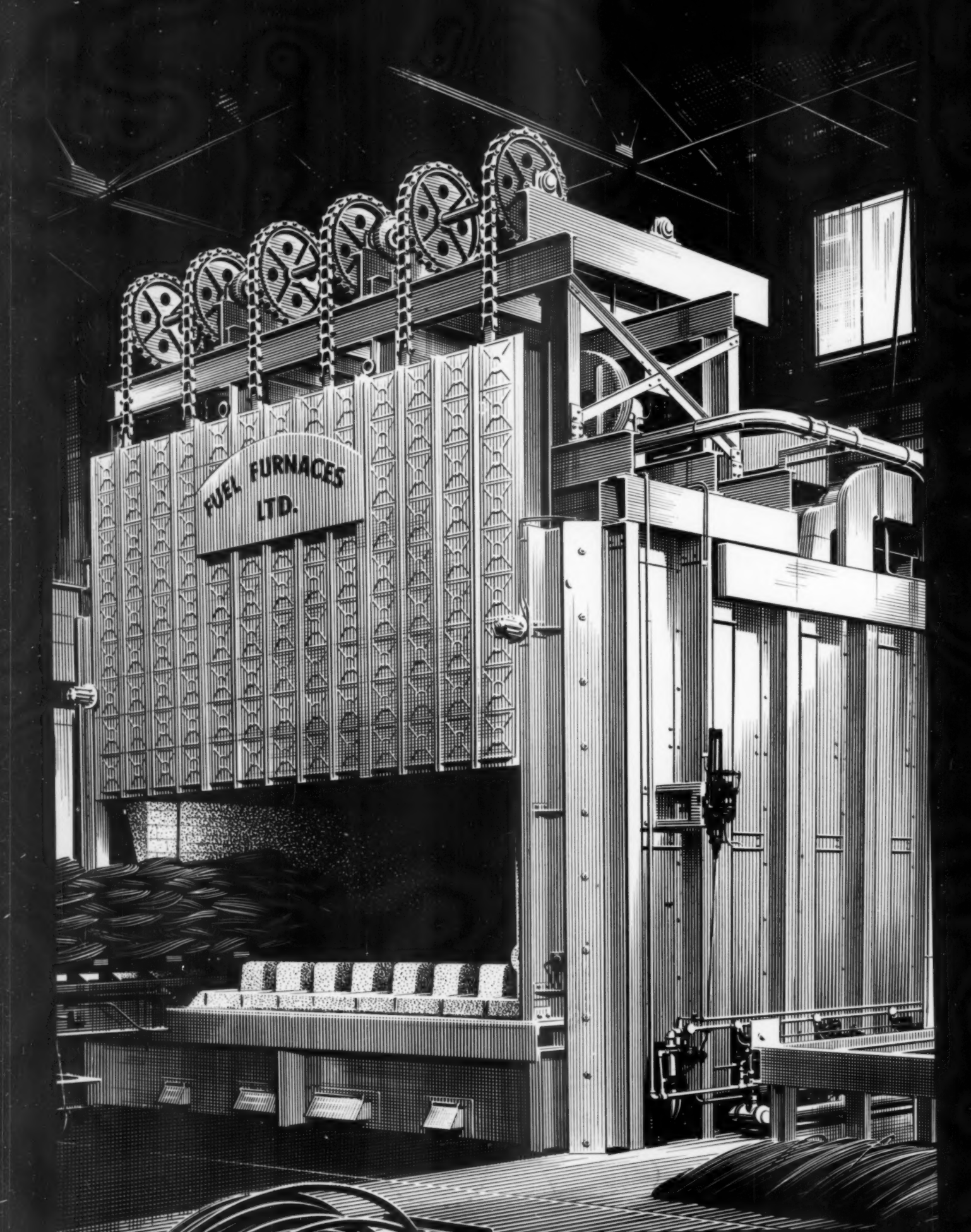
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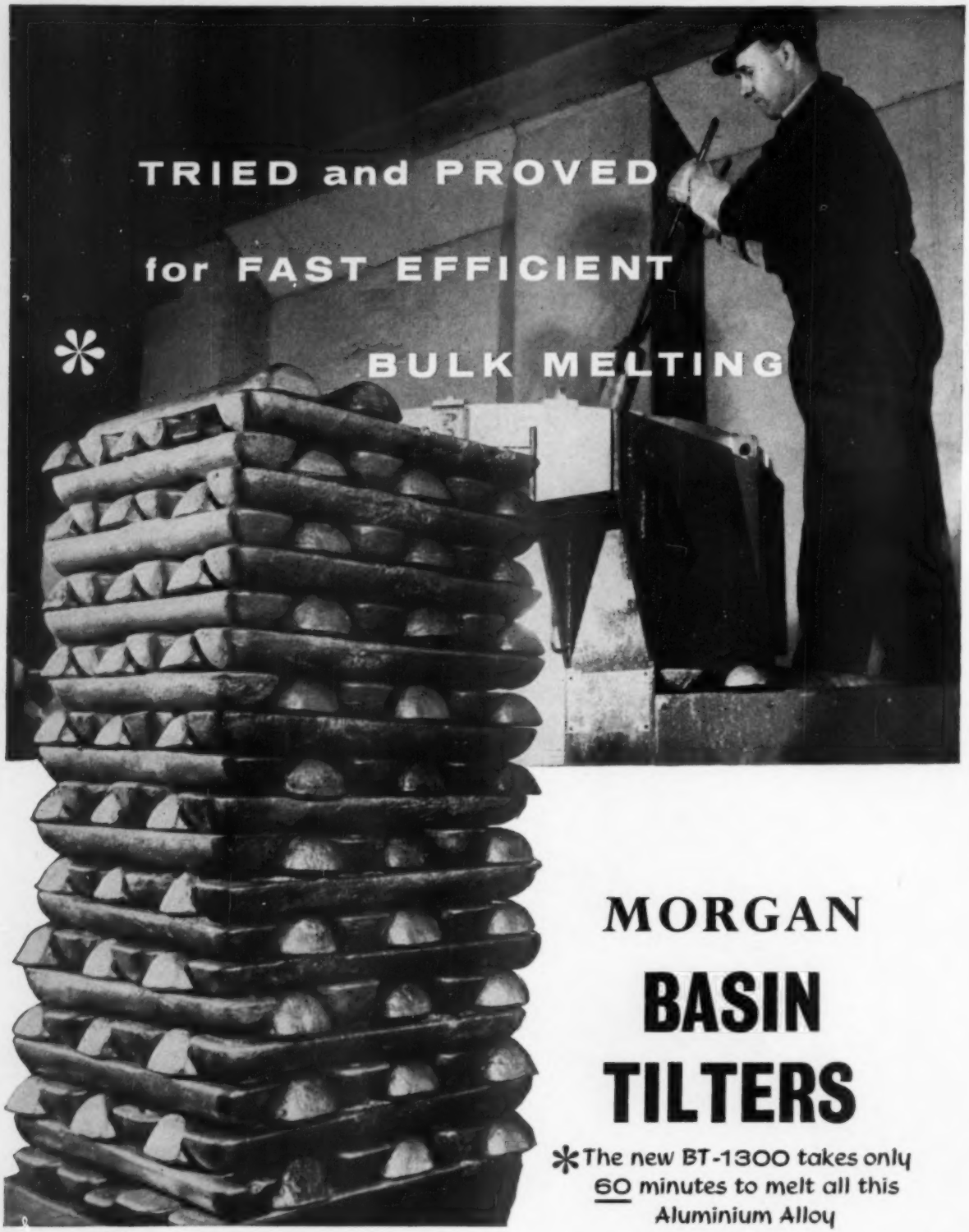

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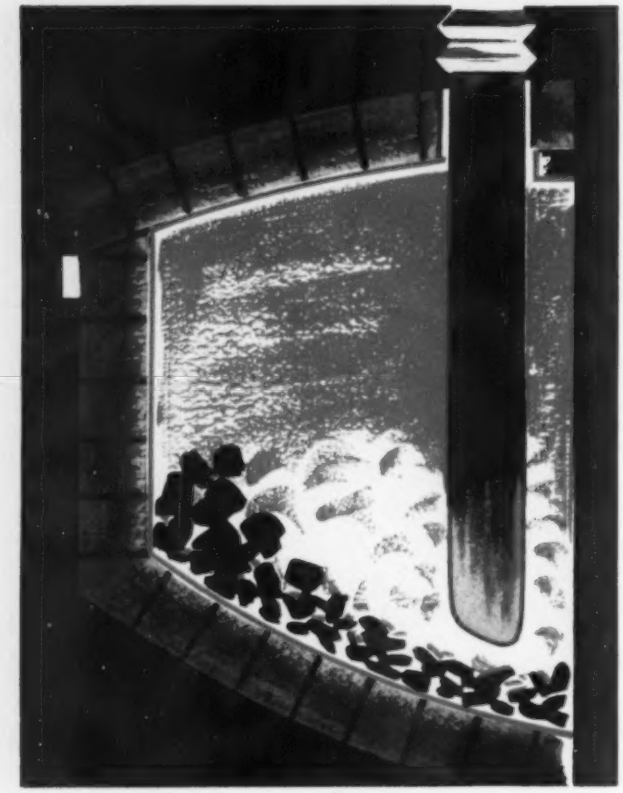

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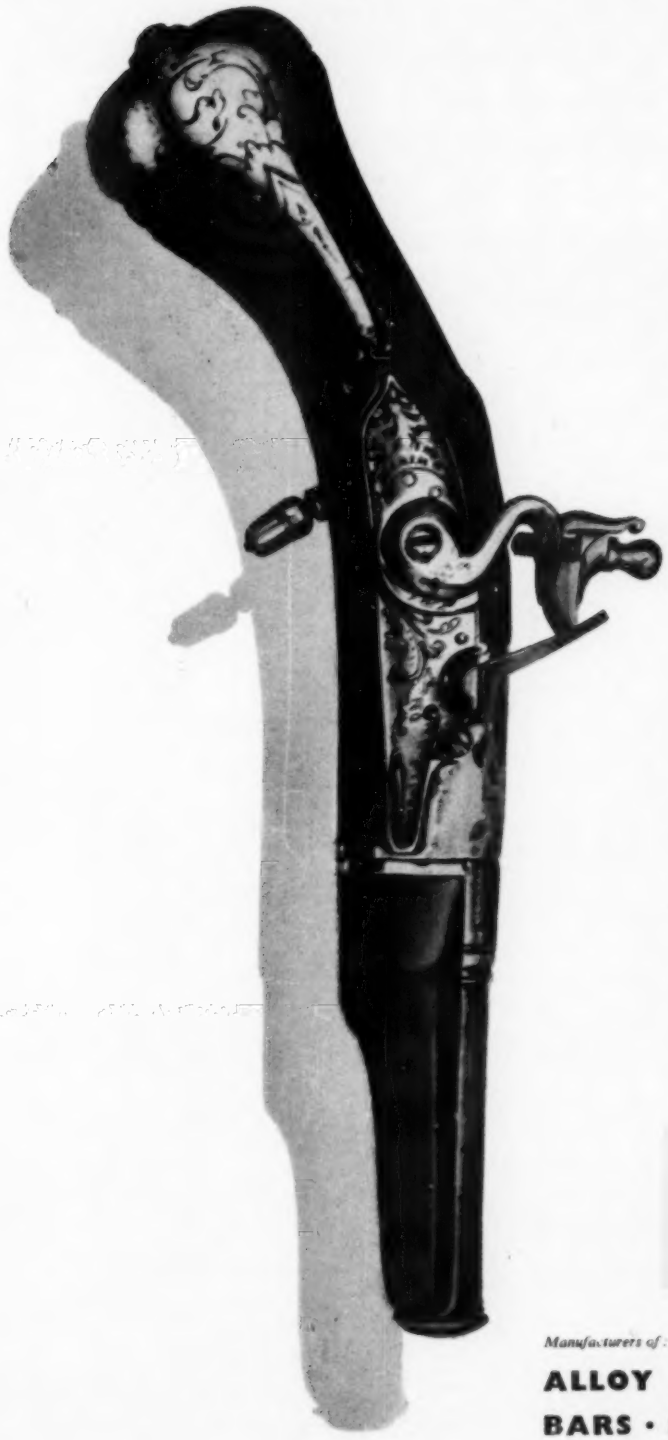

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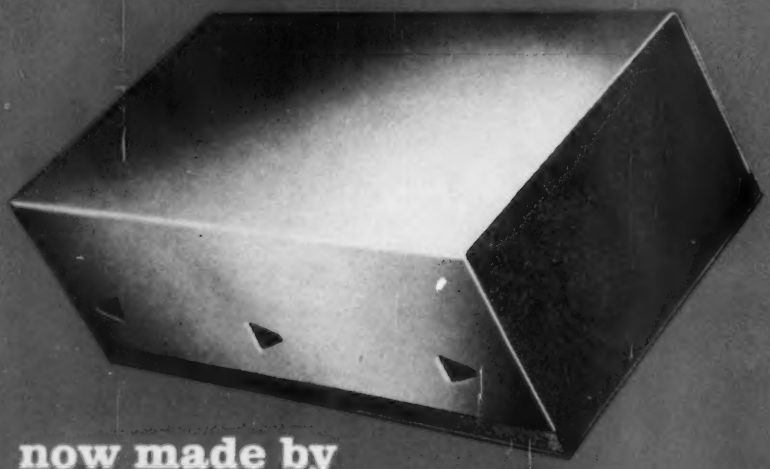

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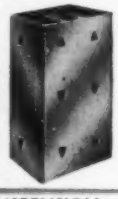

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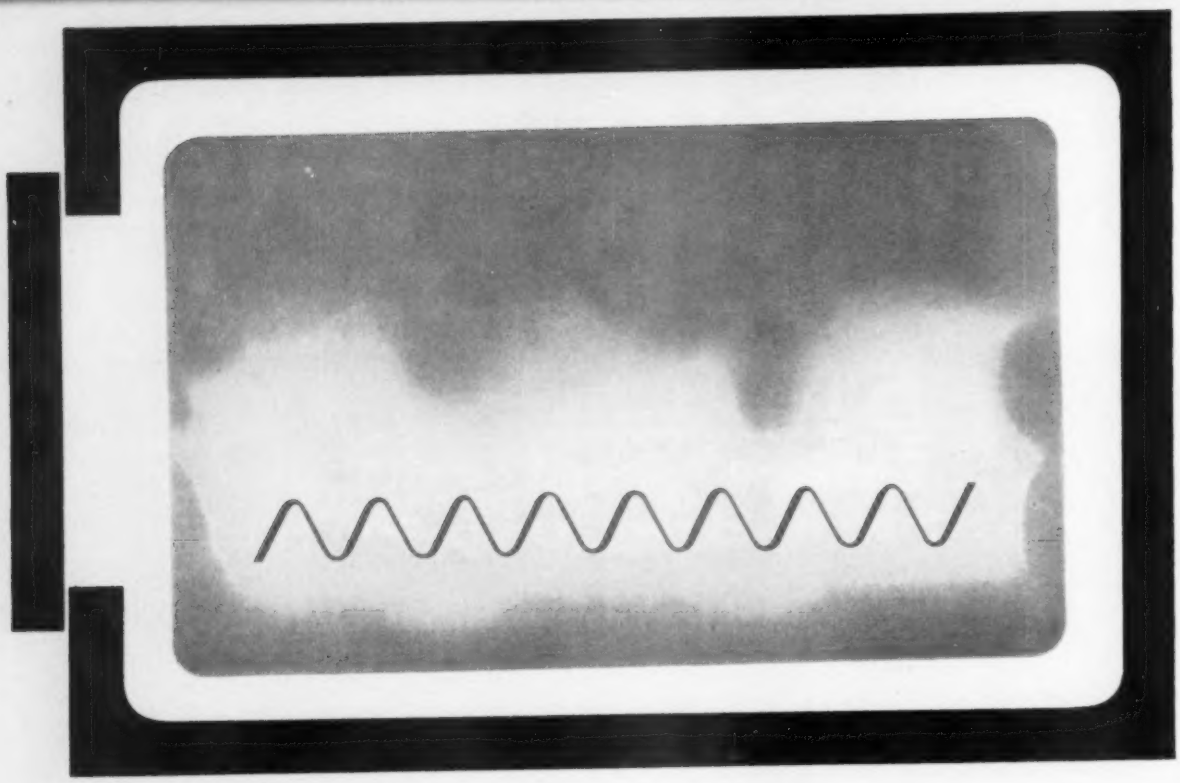

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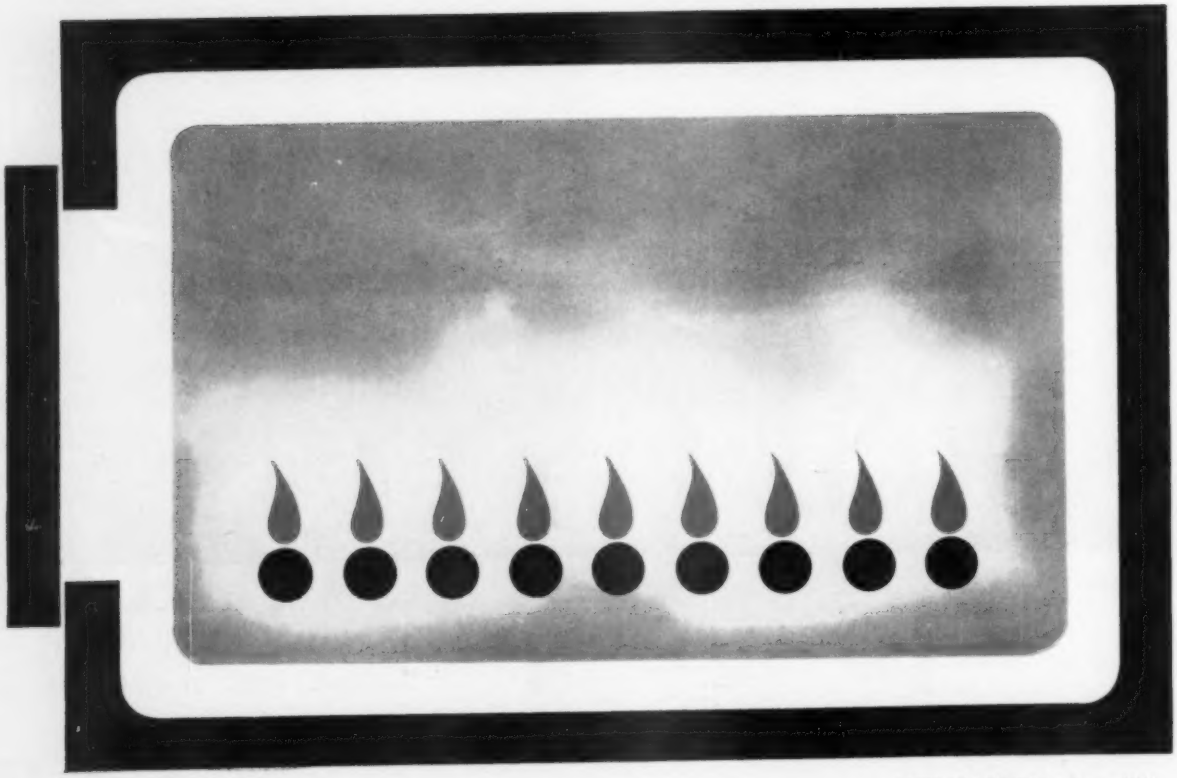

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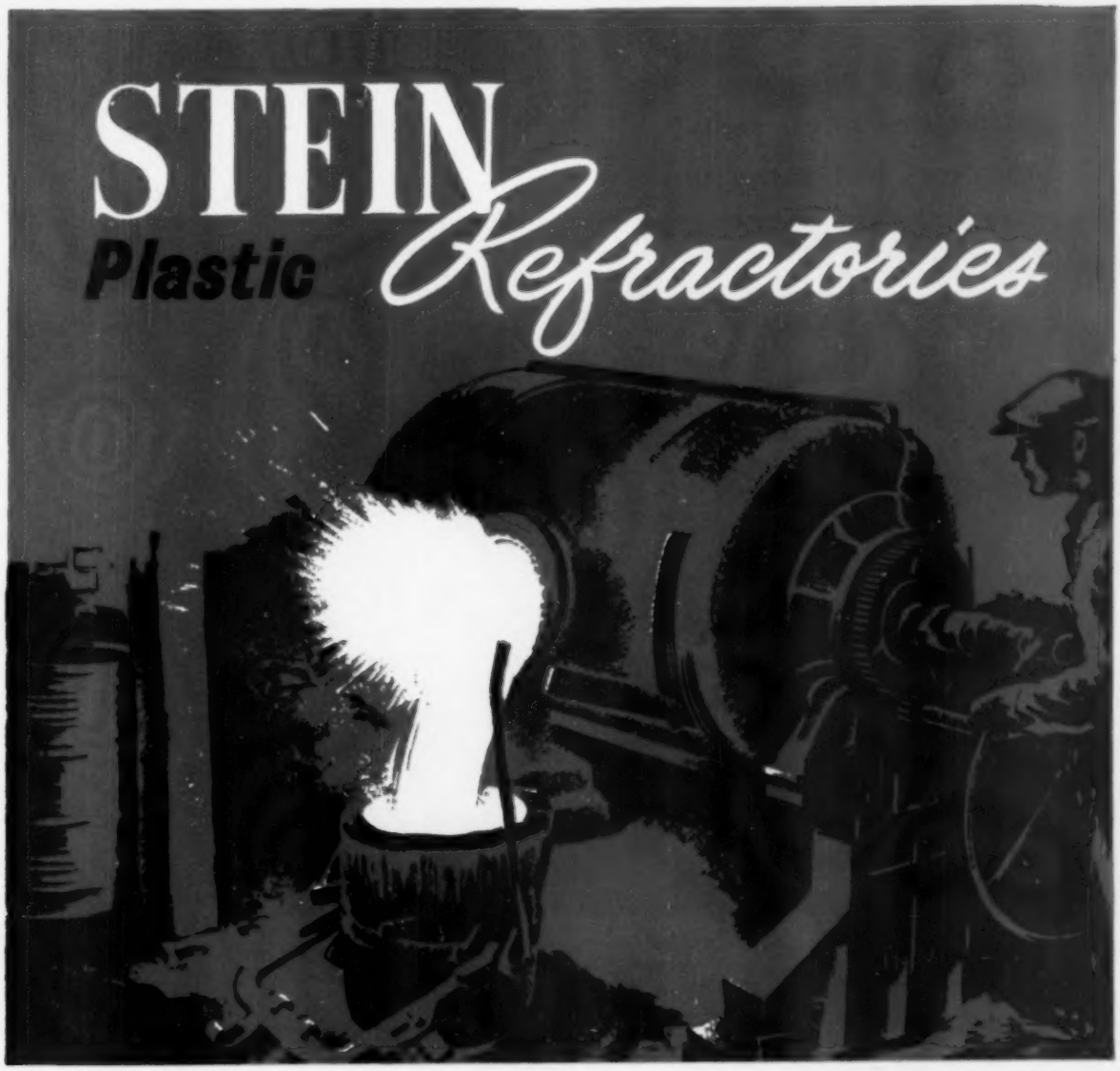

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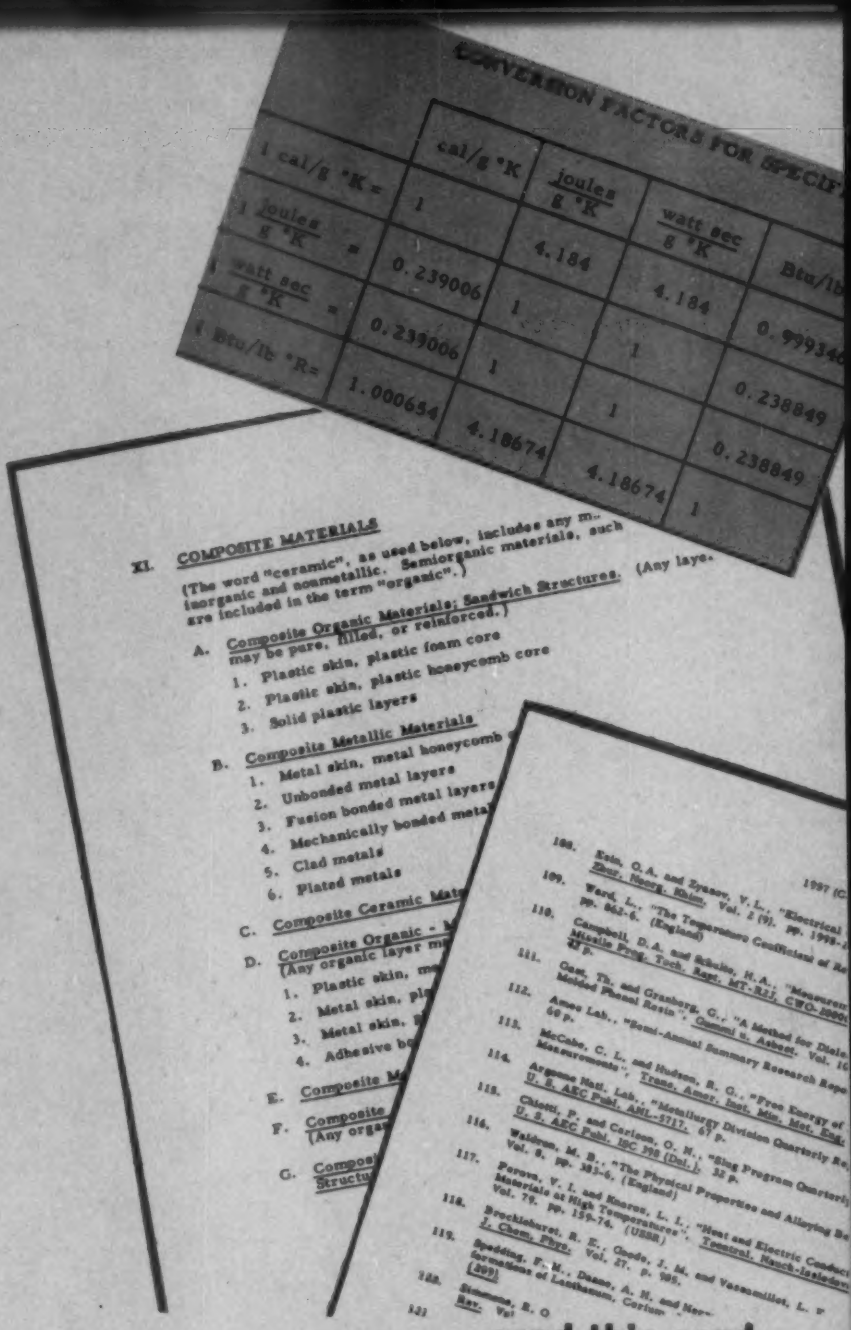

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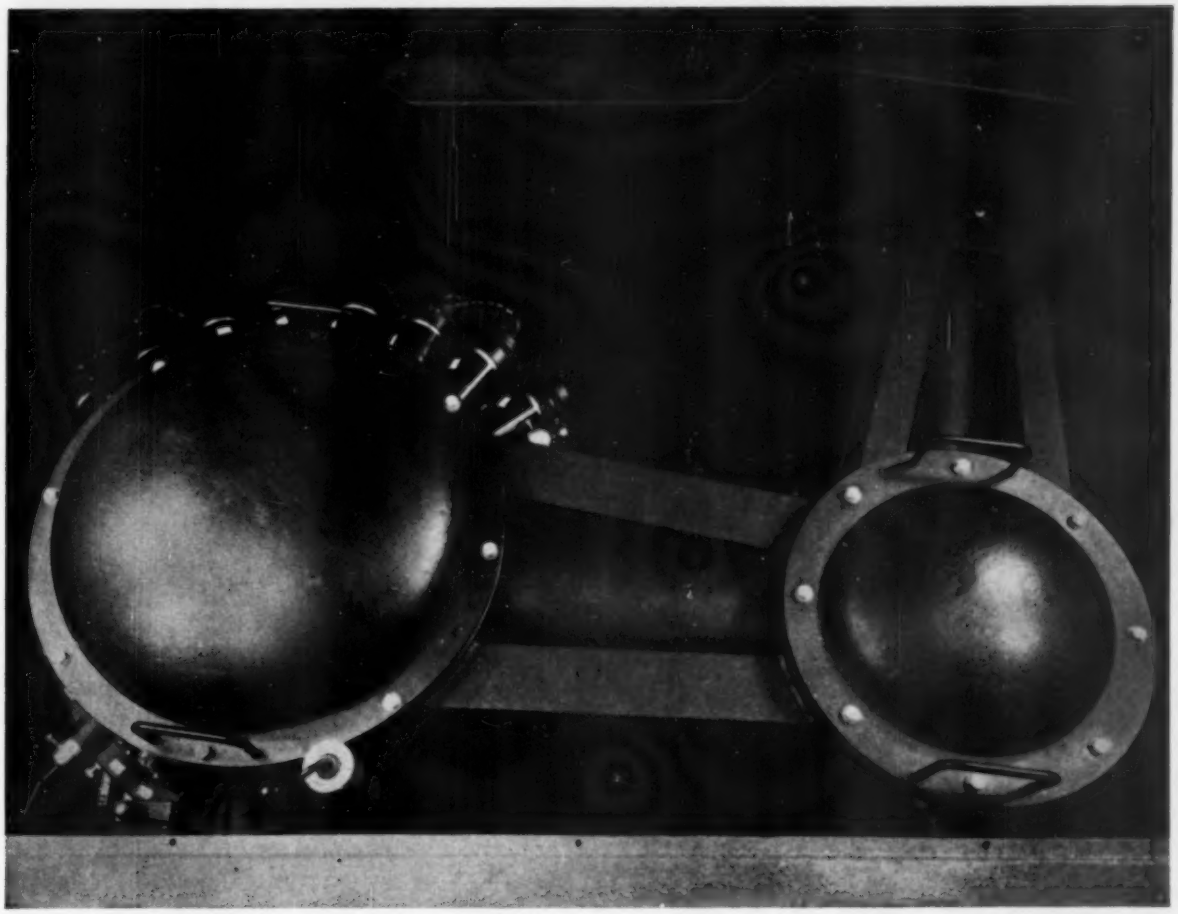

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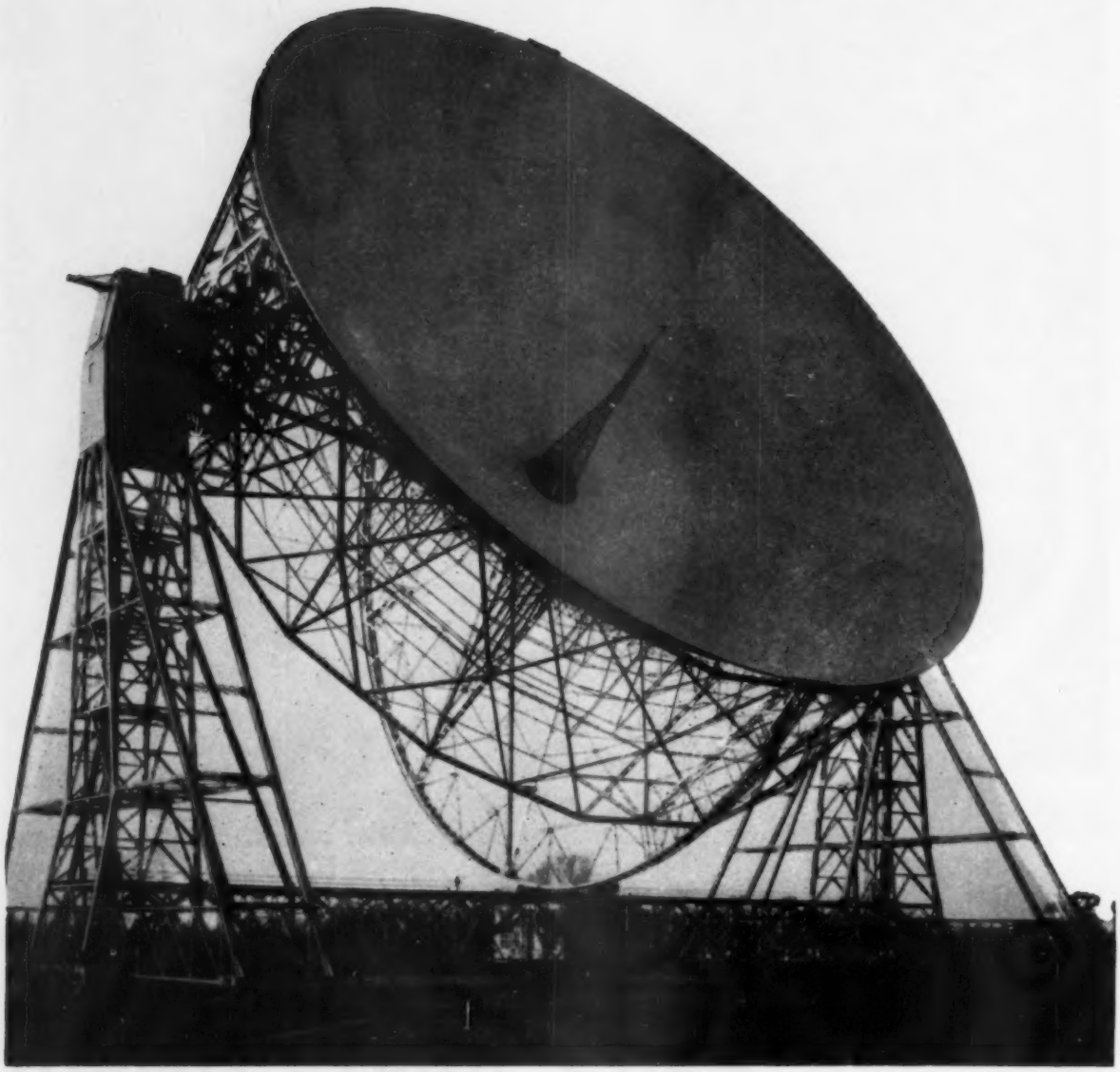

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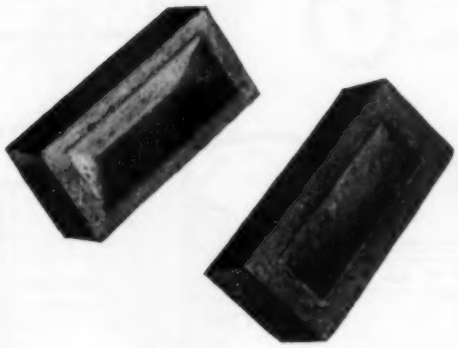

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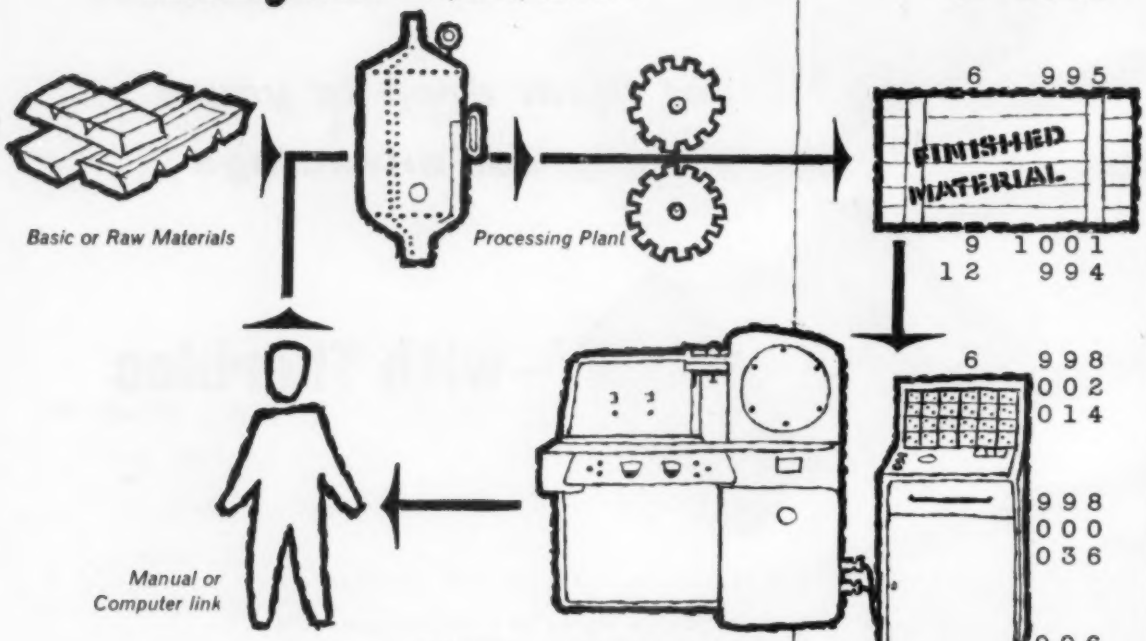

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METALLURGIA

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INCORPORATING THE METALLURGICAL ENGINEER

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JUNE, 1961 Vol. LXIII. No. 380

Textbooks and Teaching

IN the course of his presidential address to the Institution of Metallurgists last month, Dr. N. P. Allen, F.R.S., referred to the post-war revolution in the scholastic world caused by the realisation that a much greater proportion of the population could be, and must be, educated to levels above those that had been sufficient in the past in order to support a civilisation which was becoming ever more complex. The Institution had taken a part in the revolution, for its main driving force had been the desire of young men to obtain a marketable qualification. By providing the means, the Institution had become obliged to decide what kind of attainment should be recognised, and consequently the nature of the ideal that should be held before the young men throughout the teaching to which they submitted themselves. Dr. Allen then went on to talk about the importance of good teaching and of good text books.

"It is very remarkable," he said, "that the best description of the emotions that lie behind all scientific and technical discovery was given not by a scientist, but by a twenty-one year old student of surgery who was in love with the idea of being a poet. It is found in the last six lines of Keats' sonnet "On First Looking into Chapman's Homer" :—

> Then felt I as some watcher of the skies
> When a new planet swims into his ken ;
> Or like stout Cortez, when with eagle eyes
> he stared at the Pacific—and all his men
> Look'd at each other with a wild surmise—
> Silent, upon a peak in Darien.

Keats knew little science. But he knew the pleasures of the life of the mind, and the impact of broadened horizons. His imagination could feel with the astronomer and the explorer. Unless our teaching can introduce our candidates to these pleasures, and turn them into responsible students, who can, throughout their lives, to quote again from the same sonnet, travel freely "in the realms of gold," we shall fall short of what we desire for them.

"How is this introduction to be effected? The student must play his part. Clearly there were many young men who opened Chapman's Homer without feeling as Keats did about it, and clearly it is important to select for training in our profession men who have the imagination and mental power to enjoy its satisfactions. But the teacher must also be able to appeal to the imagination and bring out the power, and this requires special qualities. Education is essentially contact between minds, and since reading is the readiest way of making contact with distinguished minds, and its pleasures largely the pleasures of that communication, we should be concerned to see that the books in which our subject is presented are able to inspire and develop the kind of appreciation we require.

"We now encounter a difficulty. We have all been students in our time, and have seen our subject expand immeasurably. The old books have become out of date, but we cannot look at the new books with the same eyes as those with which the present students will see them for, much as we are unable to see the difference, it must be admitted that we ourselves have changed, our cynicism is greater and our capacity for enthusiasm is less. Our standards of judgment, too, are different from what they used to be. On the other hand, we cannot rely entirely upon our memory of our own textbooks, for memory is a notorious romanticiser, and in any case makes an unfair selection from the facts.

"Nevertheless it is probably best to look back at the old books, and try to recall for what qualities we valued them, and to assess their permanent effects on our thinking. Students are very sensitive to certain qualities in their books. They like them to be reasonably weighty and good value for money, but they must not be so long and formidable as to be overpowering. They must be direct and forthright in their approach, and have a note of authority. Much arguing of the point, back and forth, is to be avoided, except in treatments which are admittedly "advanced." Padding is anathema. Personally, I never liked treatments that were so subdivided that there was nothing in each section : I liked to feel that if I had read a section I had something to get hold of, and I liked the logical thread to be clear and continuous. But the most important thing in retrospect appears to me to be that the book should afford a balanced survey of the subject and provide a framework into which subsequent advances can be fitted, that will not have to be revised as more detailed or more advanced understanding of the subject develops.

"I well remember my first reading of Rosenhain's 'Introduction to Physical Metallurgy,' which was given to me as a school prize after I had announced my intention of going in for this then rather outlandish subject. When I saw the constitutional diagrams of the copper-zinc and copper-tin systems, which then appeared to me as terrifying, I had a queasy feeling that I had chosen the wrong line. But Rosenhain's writing was so confident and fluent, and his way of dealing with difficulties was so persuasive that I found this part of the book the most agreeable when I came to it. But I also remember a feeling of disappointment in the chapters dealing with the mechanical properties of metals, which seemed to me to be always leading up to something which never quite came. This feeling of disappointment was intensified on reading formal treatments of the mechanical testing of metals, which struck me then as being trivial, dull and self important. The modern student of metallurgy is very much more fortunate, for the work that has been done in the intervening years makes this subject more vivid and exciting than it used to be. Today's student is more likely to be overwhelmed

by too many ideas, too ill-digested, and there is still need for a good balanced book that brings the concepts of solid state physics into proper relation with the practical needs of the everyday choice of materials.

" On consideration, Rosenhain's book, though it was attractive and stimulating, was not a good text book. Rosenhain was too much concerned with the controversies in which he was immediately engaged, and this limited his outlook. There is much that needs now to be revised, and on some subjects, notably on the hardening of steel, he was definitely wrong, and had failed to appreciate the significance of the brilliant experiments of the French school of metallurgists. In this respect, Desch's ' Metallography,' which served so long as a standard text book, is much better, for there is very little in it that does not stand true today, though usually very considerable amplification would now be thought desirable. Desch wastes no words, and is always catholic, judicial and impersonal, and these are great qualities in the scholar, and reflect the qualities and high-mindedness of the man. But Rosenhain's warmth and enthusiasm are great qualities too, effective in leading to useful action. In both cases the qualities of the man shine through in the book ; there can be no good teaching unless we have also a good man, and we should take care to acknowledge the fact, and honour the teacher's qualities when we see them.

" Desch's book is full of references, and taught the value of the published literature as a store, and the use of it as a tool. His references are from all sources, and one gets from their use a sense of the large company of people, both distinguished and obscure, who have contributed to the body of knowledge, and the realisation that a truly established fact has an eternal validity, independent of the shifts of circumstance. How this is conveyed is not quite certain, for nothing is further from Desch's habit than to use rhetoric to establish an attitude.

" Another book that interested me is Roberts-Austen's ' Introduction to Metallurgy,' for it was the foundation of the introductory course in general metallurgy that I had to teach, all unprepared and driven to living on my wits, when I started lecturing at Birmingham. It was in a sense a failure, for it was before its time and attempted to unify a subject whose connecting links were not yet forged ; and it never quite solved the problem presented by the desire to teach principles and the need to give contemporary examples. But it had authority and dignity, and presented all aspects of metallurgy, even to the last chapter, in which financial speculators were reproved for the unfortunate effects of their activities upon the welfare of the industry. The book was really too short for its scope, but it served a purpose which is always needed in a technological subject, in showing the subject, in proportion, as a branch of human activity.

" For greater detail we were expected to go to Harbord and Hall for ferrous metallurgy, and to Gowland for non-ferrous metallurgy. Harbord and Hall I found more attractive than Gowland, for it is wider in its outlook and less piecemeal in its approach. It is admittedly heavy going, and I associate it with long sessions of reading in which will power played an appreciable part, but I am grateful to it for its description of the interactions between economic and technical factors, and of the grim drama of the battle between competing steel-making processes. Turner's ' Iron ' also had a place in my affections, both for Turner himself, whose aura of benevolent despotism still pervaded the metallurgy department at Birmingham when I first knew it, and for his feeling for the value of individual craftsmanship and skill, and for the sense of historical development that comes out of his book.

" I am aware that for my younger auditors, these remarks will date me irretrievably, but my choice of books has the advantage that the authors are all dead, and beyond the reach of disturbance by my praise or blame. Of later books, I notice that Hume-Rothery's two books occupy a place in the affections of all the more intelligent younger men, and that Barratt's work on X-ray crystallography is regarded as a standby, guide and friend. The one author opens gates, and is admired for the courage with which he makes it possible to understand the unintelligible ; the other classifies, arranges and systematises, but does it with such efficiency and depth of understanding as to be an education in competence. Barrett's book is quite old, but it does not date, being an example of the art of picking out that which is permanent and fundamental. Process metallurgy appears on the whole to have been rather badly served. There are plenty of heavy and exhaustive books dealing with particular industries, but few of them rise above the status of compilations, or have any vital spirit to which one can respond. Perhaps the fact that these are in many cases the semi official publications of the firms concerned, and tend to follow a stereotyped pattern, is partly responsible. Perhaps the fault is in me, in that I no longer have the imagination to respond ; but perhaps also the lack of good writing on this subject is responsible for the academic disrepute into which process metallurgy has fallen, and which is not a source of strength to the metallurgical industries of the country.

" One may reasonably ask whether text books themselves have not become out of date, and whether their place should not be taken by films, recorded dissertations on gramophone discs or tapes, broadcast talks, microprints of selected papers, seminars, conference records, and all the other self-multiplying paraphernalia of the electronic age. In this connection, a sharp distinction should be drawn between discourse, and the permanently recorded word. Oliver Wendel Holmes made a shrewd comment when he said that talking is like spraying at a target with a hose, in that the speaker can see whether he is hitting the target, and can adjust his aim accordingly but that the written word is like shooting once with a gun : the shot is either a hit or a miss. Verbal teaching involves the teacher-student relation, and it is primarily the duty of the teacher to vary his approach until he evokes a response. This interplay between teacher and student cannot be omitted without loss. But the recorded word is different. It is then the responsibility of the student to search until he understands, and it is an essential part of his education that he should learn to do so. The great advantage of reading over films, records, and all other such devices is that the student can go at his own pace, pause for reflection, turn back to confirm, or seek another authority to verify a point. In this kind of work the voice of the teacher is a superfluity, and it is profoundly true to quote Keats again, that ' heard melodies are sweet, but those unheard are sweeter.' I conclude therefore that text books will

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Cable Research

B.I.C.C.'s New McFadzean Laboratory Opened

The McFadzean Laboratory: north front and entrance.

THE McFadzean Laboratory—the latest addition to the research facilities of the British Insulated Callender's Cables group, and named after the chairman of B.I.C.C.—was officially opened on 16th May by H.R.H. The Duke of Edinburgh. It is a six-storey building providing 64,000 sq. ft. of floor space and was erected at a cost of approximately £500,000. The major part of the building is devoted to air-conditioned research laboratories, with the most modern design features and facilities for the efficient and effective carrying out of research programmes.

The power station erected at Wood Lane by the Kensington and Notting Hill Electric Lighting Co., Ltd., in 1900 was closed down in 1928, and after remaining inactive until 1931, the site was leased by Callender's Cable and Construction Co., Ltd., to provide a site for the expansion of its research section. Some of the buildings and installations were demolished and others converted for research use, and in June 1934 the Research and Outside Testing Organisation of Callender's Cable and Construction Co., Ltd., was officially opened by Lord Rutherford.

When Callender's amalgamated with British Insulated in 1945, the Wood Lane laboratories continued as the research centre of the new combine—B.I.C.C.—and from that time on, until the erection of the new McFadzean Laboratory, the plant and accommodation on the site were continually augmented to provide for the research demands of an ever-expanding group, until today a staff of some 350 is employed at Wood Lane. Still in good structural condition, several original power station buildings have been retained, and only recently has the 210 ft. power station chimney, erected in 1899, disappeared. For many years it was used for testing vertically installed cables.

The scientific and engineering forces which together form B.I.C.C.'s technical strength may be considered as being sub-divided into two main groupings—engineering and research. The engineering group has laboratories located in every production unit and the primary responsibilities of these laboratories are to exercise quality control in its broadest sense; to improve existing products, whether it be in the materials or the plant and processes which are used; to develop new products to the stage of final production; and to maintain the necessary technical contacts with customers and others.

The Research Organisation, which is concentrated in the Wood Lane Laboratories, is responsible for carrying out such long range experimental work as is necessary to feed to the engineering laboratories the information which they need to fulfil their shorter-range objectives, and to conduct basic research in fields of lasting interest, regardless of immediate applicability. In addition, the Research Organisation provides central facilities in those cases where they are required by several factories, but which demand such specialised personnel or equipment that a number of separate laboratories would be uneconomic or inefficient. The Organisation has ten experimental departments, each working in a well-defined field of science or technology, and four of these are housed in the new building: the remaining six occupy other buildings on the site. All these departments are supported by a works engineering group with its comprehensive workshops and machine shops.

The New Laboratory

The McFadzean Laboratory accommodates the instrument and control department, the physics department, British Dielectric Research, Ltd., (a group subsidiary for research on capacitors), the diffraction and microscopy department and, in addition, the electronic computer, which is an important part of the facilities of the mathematics department, the main offices of which are elsewhere. The Laboratory also contains the drawing office, the photographic section, the main conference room,

a lecture room, some administration offices and catering and social facilities.

These departments were selected as those which most need the atmospheric conditions provided by the complete air-conditioning of the new building, but which do not need extensive provision for chemical research (which is carried out in other buildings). However, to permit limited chemical or physico-chemical work, one wing of the building is equipped with chemical drainage and fume extraction.

The Laboratory has a complete basement which, besides providing accommodation for the storage of records, the electrical sub-station, refrigeration and space-heating plant and the automatic telephone equipment, provides a large space to be used for life-testing and similar long-term tests which need only occasional supervision.

Instrumentation and Control

Apart from the entrance vestibule and conference room, the ground floor is wholly occupied by the instrumentation and control department. This department is one of those which provides a centralised service to the B.I.C.C. group, and is responsible for : (*a*) developing novel measuring devices, mainly for use in the factories in non-destructive quality control testing ; (*b*) designing and constructing schemes of instrumentation, using either specially developed or conventional equipment ; and (*c*) devising automatic production equipment to replace and improve upon existing manual control methods, to improve product quality, or to economise in material usage.

The continuous vulcanisation process used in the production of rubber cables requires large and expensive plant which is unsuitable for research or development work, but a flash vulcanising unit which enables the fast vulcanising process to be studied with ease, speed, and economy has been installed in the laboratory for this purpose. Other work in progress on insulation includes a study of the use of a very low energy D.C. spark for testing rubber and plastic cable insulation in place of the more commonly used A.C. spark testing technique. Among the advantages claimed for this D.C. method are that it is non-destructive and that it is non-lethal.

In the field of metals, this department is concerned with the development of electromagnetic testing methods for quality control in the manufacture of wires and tubes, the latter being used in the production of mineral insulated cable. Tube of another kind, i.e. lead pipe, is used for cable sheathing, when it is extruded on to the cable, and for conveying fluids. Accurate control of thickness and concentricity is a vital necessity in the lead pipe to be used for the Magna flexible pipeline to convey natural gas from the mainland of British Columbia to Vancouver Island, and a continuously-operating gauge is now in its final development stages.

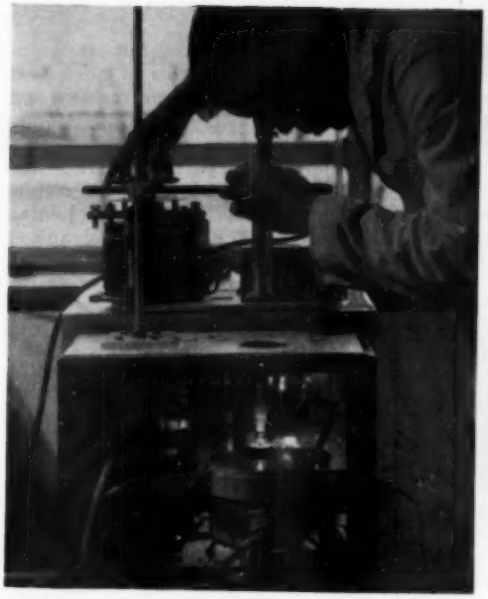
Many new devices are now available to facilitate the transport of wire through various cablemaking processes and to control quality, and one large laboratory is at present occupied by a mock-up wire processing line which includes a biflaker for controlled de-reeling of wire, and a device for temporarily storing wire in the middle of the line to allow for operations such as jointing.

The measuring head of the continuous lead sheath gauge

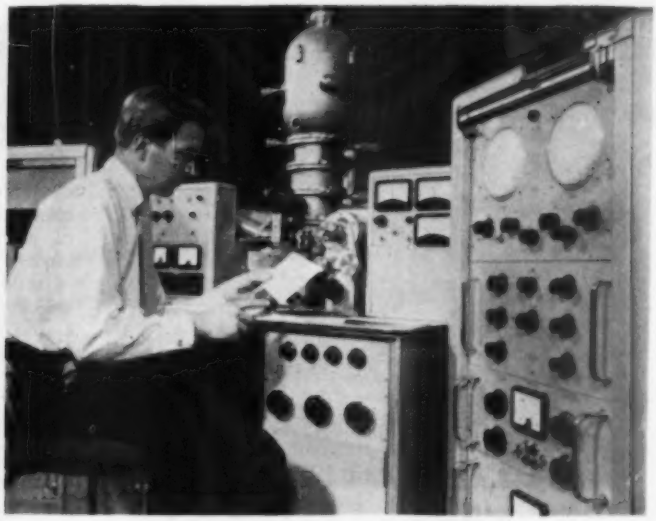
Aligning a specimen for the X-ray diffraction camera.

Physics

The physics department occupies the whole of the first floor, and nearly all of its work is of a long-range nature and largely concerned with the dielectrics used for power cables of all descriptions. The most important topic, and one in which studies have been in progress for very many years, is research into the properties of dielectrics for very high voltage cables, and the department is very well equipped for the purpose. With oil-impregnated paper dielectrics, for example, studies commence with the manufacture of the paper itself on a miniature Fourdrinier papermaking machine, which is used to study the effect of variations in processing on the quality of the paper as far as cable-making is concerned. Of necessity the department has its own high voltage testing equipment, which is normally of adequate range : where higher voltage or currents are needed, the facilities of the main high voltage department are available.



Sintering of porous tantalum anodes in the capacitor department.



The X-ray scanning micro-analyser.

Capacitor Research

The second floor is devoted to research on capacitor dielectrics, in the hands of British Dielectric Research, Ltd., which serves both the capacitor division of B.I.C.C. and the Telegraph Condenser Co., Ltd., a B.I.C.C. subsidiary. The department has sections dealing with all types of capacitor—oil-impregnated paper, electrolytic, metallised plastic, ceramic, etc.—and possesses equipment for manufacturing laboratory specimens of all kinds. It also has an extensive range of measuring facilities for the study of initial characteristics and life performance.

The self-healing characteristics of vacuum-metallised plastic film permits the use of very thin dielectrics and, hence, permits the size of capacitors to be reduced. Such metallised film may have a coating of aluminium only a few microns thick, so that the thin plastic film is comparatively "thick". In contrast, a "thin" film of dielectric can be formed on a metal foil by electrolytic treatment. The anodising of aluminium is well known as a means of protection against corrosion, but a similar technique can be used in the production of a dielectric film on the surface of aluminium foil for capacitor production. Tantalum can also be treated in this way and is, in fact, superior to aluminium in some respects. Tantalum electrolytic capacitors store better than aluminium ones, and can also be made slightly smaller. The factors governing the formation of oxide films on tantalum and the changes undergone during service are among the subjects at present being studied by B.D.R.

Some capacitor applications involve particularly arduous operating conditions, and one which is receiving attention at present is their use in energy storage capacitors in thermo-nuclear research, where they are subjected to an unusual duty cycle.

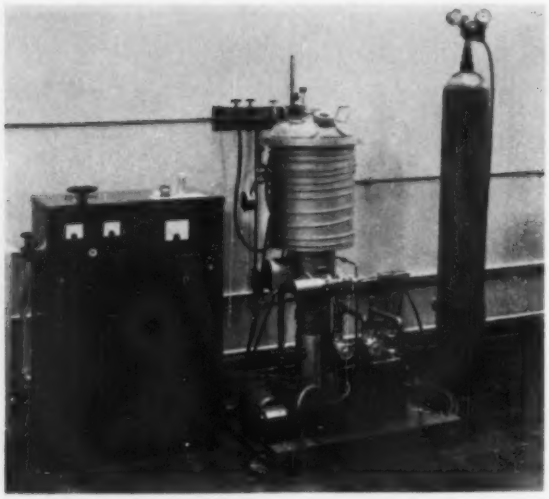
Diffraction, Microscopy and Photography

The third floor houses the drawing office, the diffraction and microscopy department, and the photographic section. The diffraction and microscopy department is concerned mainly with the fine structure of materials, and provides an analytical service of this nature to all other departments of the Organisation. It has its own research programmes, but these are mainly concerned with improvements in its own techniques.

Of the three main items of equipment, the X-ray micro-analyser is an instrument of recent development. The specimen being examined is scanned by an electron beam only 0·001 mm. in diameter. The X-rays which are generated, the wavelengths of which are characteristic of the elements in the surface of the specimen, are analysed and the results displayed either visually on the screen of an oscillograph as an "X-ray image," or automatically recorded. This enables elements which are present only in minute quantity to be located and identified. The technique is especially valuable in metallurgical studies for the examination of segregates, alloying constituents, etc., a subject of particular interest to B.I.C.C. being the alloy layer formed between a galvanised coating and the underlying steel.

The X-ray diffraction camera is used in the identification of crystalline elements or compounds and for the determination of crystal orientation and texture. The techniques are all well established but the instrument remains one of the most versatile of laboratory tools. Lastly, the electron microscope has such resolution that it permits much higher magnifications than are possible with the optical microscope, and it has, in addition, such depth of focus that stereo-techniques are readily applicable, so that photographs may be produced in three-dimensional form.

The photographic section has many duties of a routine nature, but it is also an essential part of the scientific facilities of the laboratories. Its extensive equipment includes high-speed cinematography, and photographic



The 0·5 lb. vacuum melting and casting unit.

methods are frequently used for measurement purposes. An outstanding example is in connection with the researches being carried out in the organisation's traction research laboratory at Tolworth, near London. In this unique laboratory, the behaviour of the overhead equipment used in electric railway traction is being studied by means of dynamically-similar scale models, and practically all of the measurements are being made by cinematographic or special still photographic methods.

Electronic Computer

The only laboratory on the fourth floor is that containing the electronic computer, which is used for mathematical and engineering design problems. The computer is particularly useful for the latter, because it has a much larger store than is usually needed for strictly mathematical purposes. One application which is readily understood and demonstrated is the calculation of the control requirements for installing heavy submarine power cables in deep water. The computer was first used for this purpose in 1956 when the B.I.C.C. group installed 93½ miles of 138,000 V. gas-filled cables linking Vancouver Island with the mainland of British Columbia, and an example which is now topical is the calculation of the control charts which will be used in the laying of the British section of the Cross-Channel, D.C. power cables for the England-France interconnection.

Other large projects which are in hand include the complex problem of designing minimum-cost overhead power line towers, and the calculation of the sag/tension data required in overhead line installation.

General Metallurgy

The metallurgical equipment in the McFadzean Laboratory is of a specialised nature, the main metallurgical department being located elsewhere on the Wood Lane site. This department is the centre of metallurgical research for the B.I.C.C. group as a whole, and in consequence its activities cover a wide range of metals and alloys. The building of the McFadzean Laboratory has facilitated a rearrangement of laboratories in the older buildings, with the result that the well-equipped metallurgical department now finds itself housed in reasonably spacious surroundings.

Besides the usual metallographic and testing equipment, the department possesses a number of specialised items, including an Edwards ½ lb. vacuum melting and casting unit for the production of special alloys. Among the numerous subjects which have interested, or are interesting, the metallurgical department are: the development of means of assessing the hot rolling characteristics of nickel-chromium alloys; the joining of aluminium; the design of joints on galvanised structures incorporating adhesives; the brittle fracture of mild steel in relation to towers for overhead transmission lines; and, of course, various problems associated with copper and aluminium cables and lead and aluminium sheaths.

Fouling and Corrosion of Ships' Hulls

At the seventh meeting of a group of experts from thirteen O.E.E.C. member countries* on the biological fouling and corrosion of ships' hulls, it was announced that a report on the biological and hydrological characteristics of the European testing stations participating in the group's programme will be published shortly. It was possible to gather considerable data on the rafts in use, the hydrological conditions of the water, and the nature of the fouling encountered. This information is not limited to Europe alone, data being received more recently from the United States and the British Commonwealth; the second part of this report, which is to appear at the end of the year, will deal with these extra-European testing stations. Furthermore, an international catalogue with coloured photographs and descriptions of the main marine fouling organisms found on ships coming into European ports is at present being prepared for publication.

The meeting, held at La Rochelle in close collaboration with the French "Centre de Recherches et d'Etudes Océanographiques," discussed the work of the different sub-commissions of the group engaged in detailed studies of biology and ecology of fouling organisms, standardisation of testing methods, fundamental research, and corrosion of the underwater surface of ships' bottoms related to fouling. It was decided that further studies should be undertaken to unify rafts for comparative tests of biological fouling, and that tests should be continued until 1963 to obtain comparative data with the testing stations of Spain, Portugal and the United States, countries which only recently joined the work of the group. In the field of fundamental research it was suggested to study the reaction of the different species of fouling organisms to toxins.

The work of the group forms part of the co-operative research programme of O.E.E.C. which aims at contributing to the solution of important economic problems by combined efforts of the member countries in order to get results more quickly and at less cost. Since research on marine fouling necessitates a large number of tests carried out simultaneously over a wide area and under standardised conditions, it is impossible for one country alone to carry out such tests. Hence it was particularly appropriate that a large number of countries should agree to co-operate under the aegis of the O.E.E.C.

* Belgium, Denmark, France, Germany, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, the United Kingdom, the United States, Yugoslavia.

The Effect of Manganese on the Tensile Properties of Quenched and Aged Aluminium-Copper Alloys Containing 3 and 4·5 wt.-% Copper

By V. B. Ghate, Ph.D.* and D. R. F. West, Ph.D.†

Measurements have been made of the tensile properties of wrought aluminium alloys containing 3 and 4·5 wt.-% copper, respectively, with manganese contents ranging from 0–2 wt.-%. The alloys were solution treated at 525° C. and aged for times of up to 120 days at 130° C. When aged to peak, the alloys with 0·5–2 wt.-% manganese showed a higher percentage elongation and tensile strength than the alloys with 0 and 0·2 wt.-% manganese: also they showed a tendency towards transcrystalline fracture in the peak-aged condition, as compared with the intercrystalline fracture of the latter alloys. The superior properties of the alloys with 0·5–2 wt.-% manganese are probably due to the effects of manganese on the grain size and shape, and on the ageing process. It is concluded that the presence of manganese in amounts typical of those present in commercial Duralumin-type alloys (viz. about 0·5 wt.-%) gives an improved combination of strength and ductility in the peak-aged condition at 130° C.

MANGANESE is one of the elements present in Duralumin-type and other commercial aluminium alloys. Its effects on mechanical properties, ageing behaviour and grain structure are not fully understood, and several factors are involved. The relationship between alloy constitution and ageing characteristics of two series of alloys with copper contents of 3 and 4·5%, respectively,‡ and manganese contents ranging from 0 to 2%, has been investigated by Chitty.[1] In these alloys, manganese exerts an influence through the solute content of the aluminium-rich solid solution which exists at the solution treatment temperature. At 525° C. the solubility of manganese in the solid solution is approximately 0·2% for copper contents of between 3 and 4·5%.[2] As the manganese content is increased beyond the solubility limit a ternary compound is formed, which is designated as T-phase. The amount of T-phase increases with manganese content and, correspondingly, the solid solution which co-exists with the ternary compound is depleted in copper. Chitty has reported that manganese in solid solution increases slightly the hardness of alloys in the solution treated condition (i.e. as quenched from 525° C.), and also increases the peak hardness produced by ageing at 130 or 190° C. For manganese contents beyond the solubility limit, the quenched hardness increases slightly, presumably due to the dispersed particles of T-phase. Apparently, this dispersion hardening effect exceeds the softening which would be anticipated due to the depletion in copper of the alloy matrix. In the peak-aged condition, however, the hardness decreases with increase in manganese beyond the solubility limit, this effect being presumably due to the predominating influence of the depletion of the matrix in copper.

A finely dispersed precipitate is present in various manganese-containing alloys (e.g. aluminium-manganese and aluminium-copper-manganese) which have been chill cast and then annealed: it has been termed the U-phenomenon.[3–5] The precipitate is believed to consist of fine particles of the same manganese-containing compounds that exist in larger form in the as-cast alloys, and it originates by precipitation during annealing from the supersaturated solid solution which results from chill casting. This type of precipitate has been found to be important in relation to the ageing characteristics and mechanical properties of aluminium-magnesium-silicon alloys containing additions of manganese.[6,7] In these alloys, the presence of manganese in suitable amounts reduces the brittleness and the tendency to intercrystalline fracture which are found in the artificially aged ternary alloys, and which are associated with the formation of a grain boundary precipitate of the ageing product. This beneficial effect has been attributed to a reduction in grain boundary precipitation, possibly through the particles of manganese-containing compounds providing alternative nucleation sites.

The relationship between alloy constitution and grain structure in aluminium alloys containing manganese has been the subject of a number of investigations (e.g. [8–10]). It involves the effect of manganese in solid solution, and also the effect of manganese-containing compounds. With regard to the latter, it has been found, for example, that the finely dispersed particles precipitated during the annealing of a chill cast aluminium–1·25% manganese alloy, influence the grain size of the final rolled and annealed sheet.[9] With the relatively coarse precipitate produced by an initial homogenisation at a high temperature (e.g. 610° C.) a fine ultimate grain size is obtainable in the sheet as recrystallised after mechanical treatment. With the fine, heavily concentrated precipitate which is formed when homogenisation is omitted, the recrystallised grain size tends to be coarse. It has been suggested that the fine particles inhibit recrystallisation, the extent of this inhibition being irregular due to the non-uniform distribution of the particles, and that certain grains which overcome the inhibition grow rapidly, giving a coarse recrystallised structure. It is also known that particles of Al_6Mn, of size typical of those present in as-cast structures can restrain normal grain growth after recrystallisation.[10] It appears that the grain size of wrought aluminium alloys containing manganese depends in a complex fashion on alloy constitution, and on thermal and mechanical history.

The investigation reported here forms part of a programme of work on Duralumin-type alloys, and is con-

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‡ All compositions are given in wt.-%.

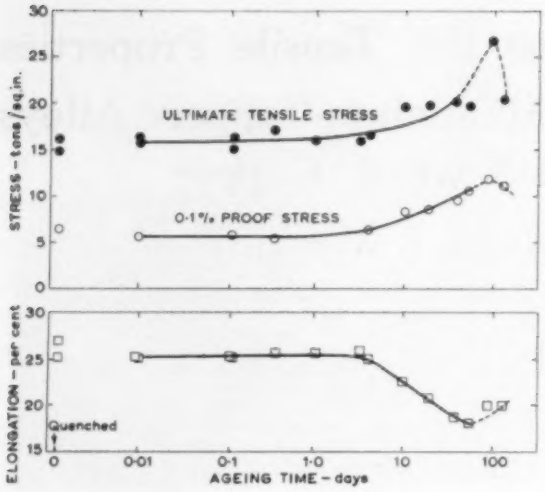

Fig. 1.—Variation of tensile properties with ageing time at 130° C. for an alloy containing 2·95 wt.-% copper and 1·05 wt.-% manganese.

cerned with the effect of additions of manganese on the tensile properties of certain aluminium-copper alloys.

Experimental Procedure

The alloy samples used were those prepared by Chitty for the investigation referred to above.[1] They were made from the following high purity materials: super-purity aluminium (99·997%); an aluminium-copper master alloy (approximately 50% copper) prepared from electrolytic copper and super-purity aluminium; and an aluminium-manganese master alloy containing approximately 9·5% manganese, 0·004% silicon and 0·03% iron. Their compositions, as determined by chemical analysis, are shown below and constitute two series having copper contents of 3 and 4·5%, respectively, with manganese contents ranging from 0 to approximately 2%.

Copper %	2·92	3·05	3·25	2·95		
Manganese % ..	—	0·22	0·53	1·05		
Copper %	4·25	4·60	4·60	4·60	4·50	
Manganese % ..	—	0·21	0·52	1·05	1·90	

Portions of the ingots, which had previously been annealed and hot worked at 490° C., were rolled from $\frac{3}{4}$ in. plate into sheet of $\frac{1}{16}$ in. thickness. Tensile test pieces of 1 in. gauge length, and $\frac{3}{8}$ in. width, were cut longitudinally from the sheet. After solution treatment at 525° C. for a minimum time of 48 hours in an air-circulating furnace, the test pieces were quenched individually into water at 20° C. Ageing treatments at 130° C. were then made, for times ranging up to about 120 days. Tensile tests were made on both quenched and aged samples, using a Hounsfield tensometer and a dial gauge extensometer. The 0·1% proof stress, the tensile strength, and the percentage elongation on 1 in. were measured.

Ageing curves, showing the variation of properties with time of ageing were determined. A high degree of accuracy cannot be claimed, as the number of specimens available for each alloy was small (averaging about 15), but the general trends of the curves were found. Duplicate tests for identical conditions of heat treatment were made in a few instances, e.g. for as-quenched test pieces, where reasonable agreement was obtained.

Results

Ageing Curves for Ageing at 130° C.

The curves of 0·1% proof stress/ageing time for the alloys of the 3% copper series were single stage in nature (e.g. Fig. 1); in the 4·5% copper series there was a tendency towards two-stage curves (e.g. Fig. 2). The highest values of proof stress were generally obtained from test pieces aged for about 80 days, but in view of the small amount of data the exact values of peak proof stress cannot be stated. It is considered, however, that the values given serve as a useful basis for comparing the properties of the various alloys in the condition corresponding approximately to peak ageing.*

The tensile strength/ageing time curves for the 3% copper alloys were of the single stage type. In the 4·5% copper alloys there was some indication of a two-stage hardening sequence; however, this was not evident in every case (e.g. Fig. 2), possibly due to the scatter of the results. Generally, an ageing treatment of about 80 days gave the highest tensile strength, and the results quoted below (Figs. 3 and 4) were usually obtained from single specimens aged for this time.

The percentage elongation/ageing time curves generally showed a period during which the elongation was approximately constant, after which it decreased and reached its lowest value at about 80 days' ageing.

Microscopical Observations

In the quenched condition, alloys with manganese contents of 0·5% or more contained particles of T-phase; the U-phenomenon was noted. In the alloys with only

* It is of interest to note that Chitty found that the peak hardness at 130° C. in the various alloys was attained in times less than 80 days, e.g. in approximately 45 days in the binary alloys.[1]

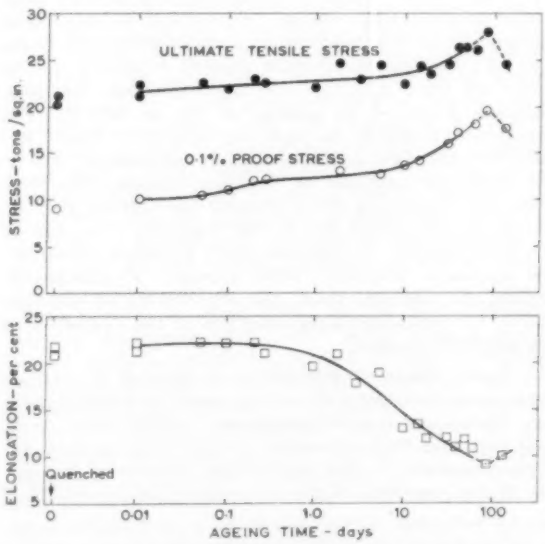

Fig. 2.—Variation of tensile properties with ageing time at 130° C. for an alloy containing 4·6 wt.-% copper and 0·2 wt.-% manganese.

0·2% manganese, it was difficult to confirm the presence of T-phase, since the composition lies approximately at the solubility limit; it may be assumed that virtually all the manganese was in solid solution.

In the binary alloys and in those with 0·2% manganese, the grains were large and approximately equiaxed (approximately 10–20 grains/sq. mm. as measured on longitudinal vertical sections of the sheet). The alloys with higher manganese contents showed a trend towards a smaller average grain size, although in some cases the grain structure was not uniform. The grain refinement was most pronounced in the alloy with 4·6% copper and 0·5% manganese, which averaged about 300 grains/sq. mm.: the other alloys had grain sizes ranging from about 20 to 100 grains/sq. mm. Also, with manganese contents of 0·5% and more, the grains were flattened and their boundaries tended to be irregular in outline. The ratio of length/height of the grains in the longitudinal sections generally averaged roughly 4/1, but was only about 2/1 in the alloy with 4·6% copper and 0·5% manganese.

In all the alloys in the quenched condition, the fractures of the test pieces were of the transcrystalline type. After ageing to peak, the test pieces of the binary alloys and of the alloys with 0·2% manganese showed essentially intercrystalline fractures. In the peak-aged alloys with higher manganese contents the fractures appeared to be more transcrystalline in nature: (of these alloys, only the one with 4·6% copper and 0·5% manganese showed marked intercrystalline features, but even in this case the fracture was partly transcrystalline).

Discussion and Conclusions

The variation of grain structure with manganese content in the alloys examined is not fully understood. Manganese in solid solution appears to have little effect on the grain size. However, alloys containing manganese in excess of the solubility limit show a trend towards a finer grain size, the effect being particularly marked in the alloy with 4·6% copper and 0·5% manganese; also, the grains are flattened and their boundaries are irregular in outline. These effects on grain size and shape are presumably attributable to the influence of dispersed

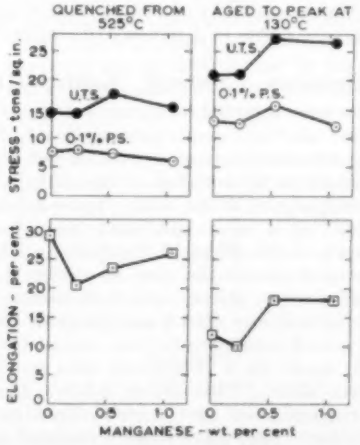

Fig. 3.—Variation of tensile properties with manganese content for a series of alloys containing 3 wt.-% copper.

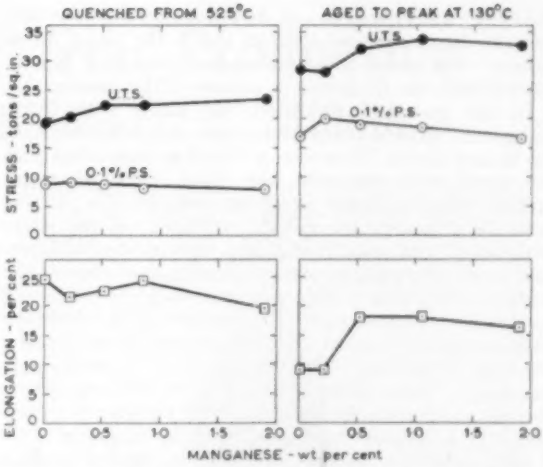

Fig. 4.—Variation of tensile properties with manganese content for a series of alloys containing 4·5 wt.-% copper.

particles of T-phase on recrystallisation or grain growth, or both. Variation, with alloy composition, in the number and size of these particles is possibly significant, in that the grain refining effect may be most pronounced for a certain relatively critical dispersion. The particle dispersion is dependent on the thermal and mechanical treatment, and further work is needed to determine the influence of the various factors on the grain structure.

The variation of mechanical properties with manganese content for the alloys in the quenched and peak-aged conditions is shown in Figs. 3 and 4, and is discussed below in relation to alloy constitution and grain size.

The addition of 0·2% manganese to the binary alloys raises the proof stress slightly. The alloy with approximately 3% copper and 0·2% manganese, as-aged, appears exceptional in this respect, but it should be noted that the proof stress value shown is for 100 days' ageing (i.e. ageing beyond the peak), as no 80-day value was obtained. A solid solution strengthening effect is to be expected with the addition of 0·2% manganese. However, it cannot be stated with certainty that the observed change in proof stress is due to this effect, since the increase is small and, in both series of alloys, the actual copper contents of the ternary alloys are somewhat higher than those of the binary alloys. With manganese contents in excess of 0·2% the proof stress decreases slightly. (The alloy with a nominal composition of 3% copper and 0·5% manganese is an exception to this generalisation, but it should be noted that the actual copper content, namely 3·25%, is higher than that of the binary alloy.) This decrease may be attributed to the depletion in copper of the aluminium solid solution due to the formation of T-phase. The presence of finely dispersed particles of T-phase, and also the refinement of grain size in these alloys, would be expected to increase the proof stress to some extent, but it appears that the decrease in copper content of the solid solution is the predominating effect.

With regard to tensile strength, no definite conclusions can be drawn as to the effect of manganese in solid solution. In the alloys with manganese contents beyond the solubility limit the tensile strengths are higher than in

the binary alloys, and do not show a steady decrease with increase in manganese content as do the proof stress values. The trend of results cannot, therefore, be correlated with the depletion in copper of the matrix.

In the quenched condition, the alloys with 0·2% manganese show a lower percentage elongation than do the binary alloys. However, as noted in connection with the proof stress variation, the effect cannot be interpreted with certainty as being entirely due to the presence of manganese in solid solution. In the alloys with 0·5% and more manganese, the as-quenched percentage elongation is generally somewhat less than in the corresponding binary alloys. Considering the peak-aged condition, a significant effect is apparent in the variation with manganese content of the percentage elongation and the type of fracture. The presence of 0·2% manganese has only a small effect, but with 0·5–2% manganese there is an appreciably higher ductility than in the binary alloys (viz. approximately 16–18% as compared with 9–12%) and the fracture tends to be transcrystalline rather than intercrystalline. The higher ductility of these ternary alloys is associated with a higher tensile strength also. Similar results have been reported for aluminium-magnesium-silicon-manganese alloys.[6]

These differences in properties with varying manganese content in aluminium-copper-manganese alloys are probably due to the effects of manganese on the grain shape and size, and on the ageing process. Low ductility and intercrystalline fracture in peak-aged aluminium alloys are associated with the existence of grain boundary precipitates and solute-depleted zones adjacent to the grain boundaries.[11,12] In the alloys with 0·5–2% manganese, the elongated alignment of the grains parallel to the principal stress axis in the tensile test specimens is such as to lessen the stress concentration effect at the grain boundaries, and hence to reduce the tendency for failure to occur along the relatively weak grain boundary regions. Also, the finer grain size gives a greater grain boundary area for nucleation of the ageing products, and should thus lead to a lowering of the concentration of precipitate per unit area of grain boundary. A similar reduction in the grain boundary concentration of precipitate may be brought about by the fine particles of manganese-containing compounds, distributed throughout the grains, acting as nucleation sites.[6] This reduction in the concentration of grain boundary precipitate, and consequently in the extent of the solute-depleted zones, should reduce the tendency to grain boundary fracture, and should favour higher ductility and tensile strength.

The results of the present investigation indicate that, in the wrought aluminium-copper alloys studied, the presence of manganese in amounts typical of those found in commercial Duralumin-type compositions (viz. about 0·5%) gives an improved combination of strength and ductility in the peak-aged condition at 130° C.

Acknowledgments

This paper is based on part of a thesis submitted by one of the authors (V.B.G.) for the Ph.D. degree of the University of London.

Acknowledgments are made to Dr. A. Chitty, who prepared the alloy ingots; to the British Aluminium Co., Ltd., who carried out chemical analysis; to Dr. M. S. Fisher, Dr. A. R. Bailey, Mr. J. G. Tweeddale and Mr. A. Cibula for helpful discussions; and to Professor J. G. Ball for providing laboratory facilities.

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Patent Office Report

THE Comptroller-General's Annual Report* on the work of the Patent Office in 1960 refers to the continued increase in applications for patents and trade marks and in applications from other countries. More than half the complete specifications to be examined now come from abroad. Despite the rise in the number of complete specifications to be examined, there were 1,759 more than in 1959, the arrears of unexamined specifications had fallen nearly 400 by the end of the year. This is the first time for eight years that there has been a reduction.

The Comptroller refers to public comment about the length of time it takes to obtain a patent. He points out that although the initial delay in the Patent Office is still too long, the Office is not responsible for the 3–3½ years after the filing of the complete specification which is often quoted as the time needed to obtain a patent. If the applicant deals promptly with questions raised by the Office an application can be accepted and published within 18 months; 50% of the applications are in fact accepted within 2 years. But one applicant in five takes so long that his application is not accepted in less than 3 years; in 1960 over 2,000 people paid an extra fee in order to be allowed an extension to 3¾ years.

Reference is made in the Report to international activity in industrial property matters, including preliminary consideration, under the auspices of the Council of Europe, of the possibility of a single patent application giving monopoly rights in a number of countries.

* "Patents Designs and Trade Marks—78th Report of the Comptroller-General for the year 1960" (House of Commons Paper 197) obtainable from H.M. Stationery Office, Kingsway, London, W.C.2 and branches, price 1s. 6d. (by post 1s. 8d.).

Continuous Casting Automation

AN order has been received by Honeywell Controls, Ltd., London, from the Continuous Casting Co., Ltd., for the complete instrumentation of a twin-strand continuous casting machine to be installed at the Abbey Works of the Steel Company of Wales, Ltd. The machine will be instrumented by a new integrated two-wire electric system known as the ElectriK Tel-O-Set. The system will control and record the flow of cooling water and lubricant at various points, and will monitor certain local flows; it will also record and integrate the casting speed and record temperature rises across the moulds. Provision is made for a Honeywell data handling unit to be fitted later. This order follows Honeywell's official introduction of the ElectriK Tel-O-Se tsystem earlier this year. They have already received a £300,000 order incorporating the system for the 720-mile Northern India pipeline project.

Special Quality Pig Iron Production

New Blast Furnace Blown-in at Millom

THE West Cumberland iron and steel industry owes its existence to the local high quality hematite ore, but, although it is still mined, this material is no longer available in sufficient quantity to keep in full production the blast furnaces at Workington and Millom ; it has, therefore, to be supplemented by high grade ores imported from overseas. The Workington furnaces form an essential part of The United Steel Cos'. integrated steel works, and much of the output is converted into steel in the adjoining acid Bessemer plant. At Millom, on the other hand, the furnaces are operated by The Millom Hematite Ore and Iron Co., Ltd., for the production of high grade hematite pig iron and other special quality irons used elsewhere.

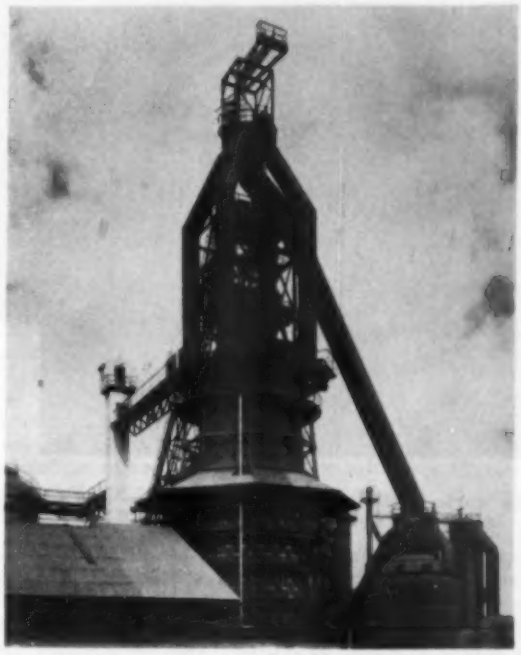
The ninety-four-year-old Millom company is the largest producer in the United Kingdom of such classes of iron, and its plant comprises three blast furnaces. The newest of these (No. 1) was lit on 3rd May, 1961, by Mr. David Blank, chairman of the Cranleigh Group —of which the Millom company is a member—at a ceremony attended by many of those who will be using the products of this new unit in steel works and foundries throughout the country.

Built at a cost of £500,000, the new furnace has a production capacity of up to 800 tons of hematite pig iron per 24 hours, or about 5,500 tons a week. This, together with another furnace with a weekly production of 3,500 tons a week, gives the works a possible output of 9,000 tons a week. A third furnace—a hand-charged 14 ft. hearth diameter unit—was blown-out at the end of April after making over a million tons of iron in the eight years that have elapsed since it was blown-in on 11th April, 1953. During its long period of continuous operation the furnace has consumed 813,142 tons of coke and 1,861,420 tons of ore and other materials. This involved the filling, pulling, hoisting and emptying of more than 5 million barrow loads. These figures are quoted as a background to the statement that the new furnace is mechanically charged by one man, and can produce twice the tonnage of older, hand-charged furnaces requiring the labours of nine or ten men. The company have emphasised, however, that the mechanical charging of the new unit will not cause any labour redundancy at the works.

In addition to the furnace itself, the installation includes a double skip hoist complete with all necessary charging apparatus, coke weighing and screening, scale-car and bunkers, connecting mains and valves, etc., the main contractors being Wilfred Marley, Ltd., of Workington. The design incorporates a number of special features, to which reference will be made in the following description of the furnace and its charging equipment.

Bunkers

The bunker range is 175 ft. long, comprising eleven bunkers in all, including two coke bunkers of 21,000 cu. ft. total capacity and nine bunkers for other materials of 28,000 cu. ft. total capacity. These capacities allow for not less than 12 hours' supply of burden materials.



This general view of the new No. 1 blast furnace at Millom shows the unusual stack column construction.

The materials are delivered to the bunkers in drop-bottom wagons. Each coke bunker has one centrally placed discharge point. All other bunkers have double-end partitions with vertical walls, and are provided with double-lip type gates operated from the scale-car.

The coke bunkers, which have a Gunnite lining, are placed centrally over the skip pit, and from each a conveyor feeds coke over a static screen to a weigh hopper. The feed to these hoppers to required quantity is under automatic control, and the weight is automatically shown by an indicator and recorded on a tape. Discharge to skip is by air-operated gates controlled by the scale-car operator. The screening rejects are discharged through a disposal chute into a small skip hoist, which delivers into a rejects hopper. This apparatus is also automatically controlled. All other materials from the bunkers are dealt with through the scale-car.

Scale-Car

The scale-car is of the contractors' standard type, with a single 110 cu. ft. capacity weigh hopper, and incorporates a four-wheel, spring-mounted chassis. The car is electrically operated by a totally enclosed traction unit and runs on standard gauge track, closely supported on steel sleepers laid in concrete. Compensated pressure air brakes are fitted.

Detail and gross weighings for each charge are shown by a dial indicator and recorded on a tape. The weigh

The Marley roll-back revolving distributor with split gas seal for bell maintenance.

Skip loading stations (right) showing automatic coke charging equipment, and scale-car at bunker discharge position (left).

hopper has bottom discharge by air-operated gate of double-leaf and large area type to ensure complete emptying after each filling.

The bunker gates are also air-operated from the car by means of robust gate lifters, and the indicator and controls are positioned to give good sighting and ease of control for all operations, allowing efficient operation with a good time margin for the operator.

Hoist and Charger

The inclined hoist to the furnace is of the double skip type. The twin skips, each of 160 cu. ft. capacity, have wheels mounted on taper roller bearings and are hoisted by a 125 h.p. winch situated in the hoist house. Also situated in the spacious hoist house, are pneumatic bell-operating cylinders, sounding-rod winches, motor-generator set and the main electrical control apparatus.

The mechanical charger is of the contractors' standard double-bell, revolving-distributor type, but embodies a special feature which permits the splitting of the gas seal and rolling back the distributor and receiving hopper to facilitate quick changing of the large bell. The stock-line sounding rods are constantly in the furnace, except during main bell operation, and their movements are electrically transmitted to dial indicators and recorders, which give a constant indication and record of the stock-line movements and of the time when each charge is dropped.

Hoisting time is 45 seconds from start to stop and maximum skip rate is forty per hour. The furnace bells are compressed-air operated: the main bell is 12 ft. 11½ in. diameter, has an angle of 53° and opens 2 ft. 6 in.; the auxiliary bell is 6 ft. 6 in. diameter, has an angle of 50° and opens 2 ft. 6 ins. The main-bell hopper capacity is 810 cu.ft. and that of the distributor hopper 160 cu. ft.

All primary controls are placed in a station positioned at the bottom of the hoistbridge and convenient for the scale-car operator, who starts each skip by push-button control, following which all movements of hoisting and charging follow automatically in set pre-selected sequence or, in part independently, as desired. All operations are fully safety interlocked to prevent movements out of sequence. This interlocking also allows for "jigging" of the bells to clear obstructions in the event of the bells failing to close and seat properly.

The rate of operation of the scale-car and the hoist and charging apparatus allows for the input to the furnace for normal production to be obtained when the apparatus is working at 55-60% of its maximum rate, so as to allow ample time reserve.

Furnace

The new furnace was planned and designed with the aim of supplying a unit which would give quality and quantity of product, reduction of manual effort, uniformity of operation, reduced maintenance, and conservation of materials.

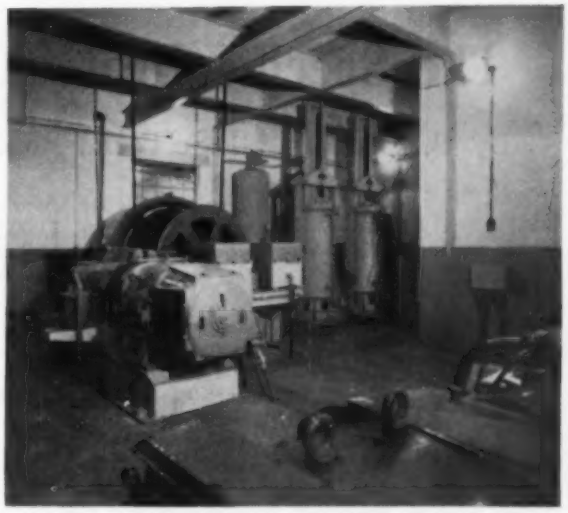
The dimensions of the furnace itself are: *well* 20 ft. diameter by 11 ft. 4½ in. deep; *bosh* 20 ft. diameter at the bottom, increasing to 24 ft. diameter at an angle of 79° 42′ through a height of 11 ft.; *stack* 24 ft. diameter at the bottom, parallel for 7 ft. 6 in., and then tapering to 18 ft. 6 in. diameter through a further height of 38 ft. 6 in.; and *throat* 18 ft. 6 in. diameter and parallel through a height of 8 ft. 6 in.; *total height* 84 ft. from the tap notch to furnace top platform level. The furnace has sixteen tuyeres fed from a bustle main 3 ft. diameter inside the brick lining.

The cooling arrangements provided on the furnace are: (*a*) for the hearth jacket and bosh—by sprays; (*b*) for the tuyere belt—by three rows of inset flat copper coolers, and (*c*) for the stack—by fourteen rows of inset flat copper coolers over a large portion of its height.

A special feature of the new unit is the provision by

Wilfred Marley, Ltd., of an economic design of stack columns arranged so that the whole of the top weight of the distribution and charging gear, together with the furnace top platform, is carried direct onto the main support columns instead of onto the stack casing. Since the cooler platforms are also carried on this structure, the arrangement involves very little extra steelwork than conventional cooler platform designs. Also, the stack plates are not as thick as would otherwise be necessary. The importance of this arrangement lies in the fact that the whole stack is free to expand and, in the event of any fracture of the casing, the top weight—which is considerable in modern blast furnaces such as this—causes no danger. Individual plates or, if necessary, the whole stack may be replaced safely without interference to the top gear. Such an operation has in fact been successfully carried out by the makers on a smaller installation.

Four gas offtakes have been provided, together with uptakes leading into a single gas box from which a single downcomer is led to a primary dustcatcher. The dustcatcher connects to existing gas mains and a suitable isolating valve has been installed. Dust discharge is either direct or through a single shaft pug mill.



Section of the hoist house showing winch (left) and high-pressure pneumatic bell-operating cylinders.

Product

In contrast with furnaces attached to steel works, where the demand is for iron of the same quality over a long period, the Millom furnaces are required to produce 'tailor-made' irons to suit the particular requirements of individual customers. With the installation of the new furnace, the company is even better placed than formerly to supply high grade hematite pig iron in almost any combination of low phosphorus, low sulphur and manganese contents to meet the varying analyses of these elements now in demand, with silicons as required.

Vanadium-Columbium Alloys

VANADIUM-BASE alloys containing 20–50% columbium display good high-temperature strength, good corrosion-resistance in both oxidising and reducing environments, and fabricability by conventional hot-working techniques in air, according to a recent report by Dr. S. T. Wlodek, Union Carbide research metallurgist. Studies of these alloys were undertaken because the high melting point and low density of vanadium suggest use of the metal in high-temperature applications where good strength-to-weight ratio is required. Vanadium also possesses good liquid metal corrosion resistance and, because all of its short-lived isotopes decay without emitting excessively strong decay products, it is often regarded as a promising structural material for nuclear applications.

Unfortunately, however, pure vanadium does not have the high-temperature strength that its high-melting point would imply, although it has excellent room temperature fabricability and remains ductile at very low temperatures. Moreover, of all the refractory metals, pure vanadium is probably the least resistant to oxidation and aqueous corrosion. These deficiencies make the hot-working of vanadium impracticable and limit its use in chemical environments. Obviously, some alloying is necessary to improve the usefulness of the metal.

Dr. Wlodek studied the behaviour of a family of alloys based on a columbium-vanadium system containing 20–50% of columbium by weight. He found that in the warm-worked condition vanadium-columbium alloys have ultimate tensile strengths of 12,000–35,000 lb./sq. in. (5·4–15·6 tons/sq. in.) over the temperature range of 700°–1,000° C., and stress-rupture properties at 700° C. corresponding to 100-hour life at stresses in excess of 100,000 lb./sq. in. (44·6 tons/sq. in.). On samples which had been warm-worked and stress-relieved, the tensile strength increased to 70,000 lb./sq. in. (31·2 tons/sq. in.) at 1,000° C., and to 40,000 lb./sq. in. (17·9 tons/sq. in.) at 1,200° C. Strain-rate sensitivity can be improved at the expense of strength by titanium additions.

Both the aqueous corrosion resistance and oxidation resistance of the alloys were also considerably higher than those of pure vanadium. Maximum oxidation resistance is obtained by titanium and aluminum additions. The increase in corrosion resistance probably resulted from the passivity inherent in columbium, which usually results in a protective film.

Foseco-Fordath, Ltd.

FOSECO INTERNATIONAL LTD., and The Fordath Engineering Co., Ltd., have announced the formation of Foseco-Fordath, Ltd., a joint company to license the manufacture and marketing of the Fordath range of core binder products in world markets outside the United Kingdom. The formation of this joint company will mean that the products of Britain's leading manufacturer of foundry core binders will now be available in all markets of the world through the extensive sales organisation of the Foseco Group, with its sixteen manufacturing and sales units and forty three distributors covering fifty one countries. Specialised foundry equipment manufactured by Fordath is not included in the agreement and will continue to be marketed exclusively by the manufacturer in all markets.

The Specific Heat of Hyper-Eutectoid Steel

By B. Gregory,* B.Sc.Tech., Ph.D. and H. J. Bray,† B.Sc.Eng., Ph.D.

A technique has been used for the derivation of specific heat values for hyper-eutectoid steel in the temperature range 500°–1,000° C. The technique involved accurate thermal analysis from which it was possible to derive a differential area curve and subsequently the specific heat curve using a radiation relationship.

THIS investigation has as its object the determination of specific heat curves for hyper-eutectoid steels, which differ from true values by only a fraction of a per cent., by means of a mathematical computation of results obtained from an accurate continuous heating and/or cooling thermal analysis. Previous work of this nature was conducted by Awbery and Snow[1] and others[2–5], and more recently by Pallister[6]. These workers measured the temperature rise of a specimen, after the introduction of a measured quantity of electrical heat provided by means of a resistance coil, and used this as the basis for their specific heat determinations.

Such methods give values of specific heat, by an intermittent process, but between comparatively wide limits of temperature, whilst those which involve the rapid cooling of specimens in a calorimeter, as pointed out by Pallister, would be found defective in the transformation region of temperature. The authors' continuous method lends itself readily to measurements in the direction of heating and cooling, thus giving a total mean specific heat curve. The values obtained were derived from an expression involving the equation of Stefan's law of radiation and a " Newtonian " law of radiation for a specimen contained within an enclosure under definite conditions.

Theory of Derived Results

Heat can be transferred from a specimen to an enclosure (or vice versa) by conduction, convection and radiation. Provided the surface area of contact between an enclosure and specimen is small compared with the total surface area of the specimen, it is assumed that heat transfer by conduction is negligible and that total heat transferred is entirely due to radiation when under reduced pressure.

Stefan's Law of Radiation may be written :—

$$J = AE\ \sigma\ (T_s^4 - T_E^4) \qquad (1)$$

where J is the radiation in calories per second, AE a complex of specimen and enclosure area emissivity coefficients, σ Stefan's constant, and T_s and T_E the absolute temperatures of specimen and enclosure, respectively.

By equating the " Newtonian " expression of radiation

$$J = K\ (T_s - T_E) \qquad (2)$$

to the Stefan expression, the constant K can be evaluated and the mathematics simplified. Thus by equating (1) and (2)

$$J = K\ (T_s - T_E) = AE\ \sigma\ (T_s^4 - T_E^4)$$

and $$K = AE\ \sigma\ (T_s^3 + T_s T_E^2 + T_s^2 T_E + T_E^3) \qquad (3)$$

This equation has two limiting approximations of opposite sign in error

$$K \simeq 4AE\ \sigma\ T_s^3 \text{ and } K \simeq 4AE\ \sigma\ T_E^3.$$

Therefore, there must be some temperature between T_s and T_E for which

$$K = 4AE\ \sigma\ T_g^3 \qquad (4)$$

K is a temperature-dependent constant and any integration concerning this must be taken into account. This difficulty can be overcome by taking a value of T_g which makes the integration correct for the desired initial and final stages and gives a good approximation for intermediate conditions, especially since at high temperatures heating and cooling take place readily under small temperature differences. Now, from (4) and (2)

$$J = 4AE\ \sigma\ T_g^3\ (T_s - T_E) = \frac{dQ}{dt} = -ms\frac{dT_s}{dt}$$

where Q is the quantity of heat radiated in calories per second, t is the time in seconds, m the mass of the specimen and s the specific heat. Therefore

$$s = \frac{-4AE\ \sigma\ (T_s - T_E)\ T_g^3}{m} \cdot \frac{dt}{dT_s} \qquad (5)$$

This can be simplified to

$$s = CT_g^3 \times \text{Area}/^\circ\text{C.} \qquad (6)$$

assuming $-\left(\frac{4AE\ \sigma}{m}\right)$ is constant for any single experiment and $(T_s - T_E)$. $\frac{dt}{dT_s}$ represents the area enclosed between the specimen and enclosure curves per increment of temperature.

In this simplified expression the constant C can be determined by comparing known values of specific heat at a few isolated points with the differential area curve. Once this value has been established the whole relationship between specific heat and area per degree centigrade can be calculated quite readily, and specific heat values found over the whole range of temperature covered by the experiment.

Thermal Procedure

An enclosure, free from thermal changes over the range of temperature covered by the experiments, was made from copper cast in two halves and subsequently machined to the dimensions shown in Fig. 1. Specimens, of analysis given in Table I, were machined into cylinders $\frac{3}{4}$ in. diameter × $\frac{3}{4}$ in. long and annealed, provision being made to admit the thermocouples to the centre of the

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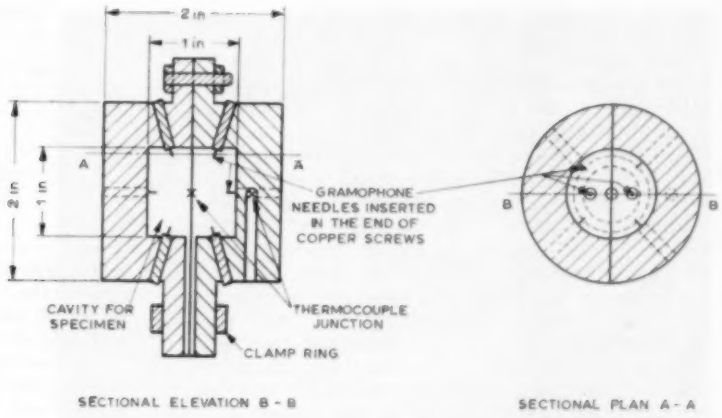

Fig. 1.—Diagram of specimen enclosure.

specimen and enclosure, securing them by means of grub screws. The specimens were centred in the enclosure with gramophone needles inserted in copper threaded screws. By this means it was assumed that radiation would, for ease of calculation, be uniform at all points on its surface, and heat due to conduction from the needle points negligible.

The specimen and enclosure were then suitably mounted on an insulated base at the centre of a furnace, the latter being heated or cooled at desired rates (0·25–5° C./min.) by means of a geared Variac control, operated from a timing device capable of giving electrical pulses. During the thermal cycle, marks were placed on a paper tape chronograph by means of a morse tapper at every 0·10 mV. increment of both specimen and enclosure thermocouple e.m.f.'s, using the well-known "null-point" technique. The temperatures were measured using Chromel-Alumel thermocouples, accurately calibrated against five fixed points and a standard platinum-platinum-10% rhodium thermocouple by a difference curve technique, in conjunction with two Diesselhorst type potentiometers.

Computation of Results

By a simple measurement of distances between successive markings on the tape, the exact enclosure temperature for any given specimen temperature (or vice versa) was calculated, and the results computed for plotting the necessary graphs. From the tape results, the value of area/° C. was calculated (a product of distance between markings and mean $T_s - T_E$) and plotted against specimen temperature. The best mean specific heat value for each of the pure elements in the steels was extracted from reference books and corrected for a temperature within the experimental range. The relationship between specific heat and temperature is of the form $s = a + bT + cT^2 + \ldots\ldots$ A separate series of experiments would have been better, but time precluded this. The value of area/° C. at this temperature is then extracted from the plot and substituted in equation 6. From this the constant C can be derived.

This value is used in the same relationship at various temperatures and the value of area/° C. obtained from the plot. The values of specific heat over the entire range can then be calculated, the number of temperatures selected depending on the shape of the plot.

TABLE I.—ANALYSIS OF STEELS USED.

Steel	C%	Si%	S%	P%	Mn%	Ni%	Cr%	Mo%
A ..	0·79	0·091	0·028	0·031	0·64	0·01	0·01	0·01
B ..	1·20	0·115	0·016	0·023	0·21	0·01	0·02	0·01
C ..	1·53	0·067	0·018	0·021	0·25	—	—	—

Results and Discussion

For the purpose of comparing the lower values of specific heat, the results for the three steels investigated are presented in Fig. 2. Owing to the difficulty of showing the peak values of specific heat graphically these are presented in Table II. From Fig. 2 it can be seen that the values of specific heat do not increase regularly with increasing carbon content. The values for steel C lie between those for steels A and B, which called for a further investigation on the specimen. A metallographic examination revealed the presence of graphite, the amount of which was determined by analysis, which revealed a value of 0·53%. This suggested that only carbon present in combined form contributes to the value of specific heat, the original graphitisation having been produced by the annealing treatment. This reasoning seems justifiable since the effective value of 1% carbon combined produces values of specific heat approximately half way between those for steel A and B. This leads to the conclusion that an

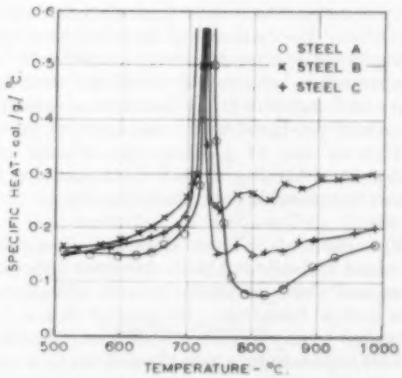

Fig. 2.—Variation of specific heat 0-0.6 cal./g./°C. in the temperature range 500-1,000 °C.

increase of carbon contents, provided it is combined, increases the specific heat in a regular manner.

Dealing with the sections of the specific heat curves above the eutectoid change, three explanations relevant to the unexpected change of slope present themselves. Firstly, the effect may be real since all three curves show this tendency. The effect becomes increasingly noticeable with increase of combined carbon content and even more so with steel B, which unfortunately includes traces of residual impurities nickel, chromium and molybdenum. Such alloying additions, together with the thermal strain on the crystal lattice of cementite and its instability at elevated temperatures, probably cause distortion of the crystal structure as a whole and the small diffusion effects become detectable thermally.

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The results however, lie in the expected order since the greater the proportion of pearlite present the greater would be the heat necessary for its transformation to austenite at this temperature.

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Non-Ferrous Metals Research

B.N.F.M.R.A.

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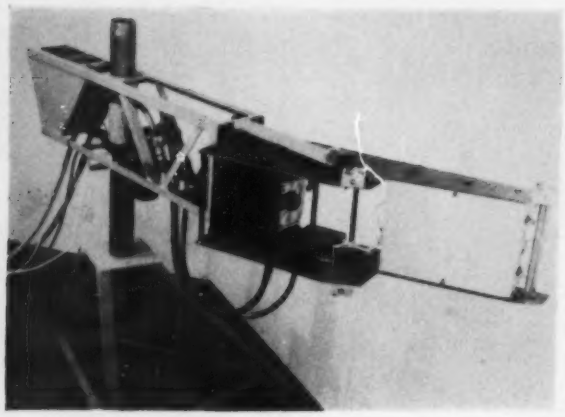


Experimental rig for measuring aluminium rolling slab temperature by radiation pyrometry.

recently the B.N.F. has been a leader in the introduction of X-ray fluorescence methods of analysis into the metallurgical industry in this country. With this technique the sample is irradiated with a beam of X-rays and the secondary X-ray emission, which is characteristic of the elements present in the alloy, is analysed with a special spectrometer. In this way a quantitative analysis of the alloy can be made rapidly, and commercial instruments are now available which allow a complete analysis to be made in a minute or two, the results being recorded on a paper tape. Particular attention has been paid to the successful development of solution methods using synthetic solutions as standards, and work is in progress on methods for powders such as ores and tailings. The most pressing remaining problem is simplification of the calibration procedure for solid samples to allow corrections to be made for inter-element effects using as few standard alloys as possible.

At present, many specifications for copper alloy tubes call for a hydraulic test for soundness, but the more-recently developed eddy current methods of detecting cracks and manufacturing faults are more sensitive and less time consuming, and there are hopes that such techniques may replace pressure testing, for some classes of tube at least. Research in this field has resulted in means of minimising the "drag" effect which occurs when products moving at high speed are inspected, and an investigation has been made of a phase-sensitive technique for distinguishing different types of fault. The possibility of automatic sorting into good tubes and rejects has been demonstrated by an experimental set-up in the laboratory.

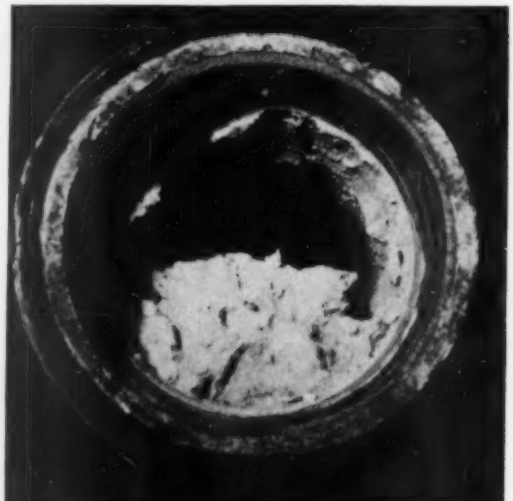
A major difficulty in the use of radiation pyrometers for temperature measurement is the error arising from variations in surface emissivity under production conditions, these variations being particularly troublesome with aluminium alloys at hot working temperatures, and with inductively heated copper alloy billets which oxidise during heating. A method of correction using a heated reflector plate to obtain more nearly black body conditions is about to undergo trials for measuring slab temperatures in an aluminium rolling mill. For use where space limitations prevent the use of radiation pyrometers a roller-contact thermocouple is to be tried industrially.

Manufacturing Processes

There is a possibility that aluminium alloys will be used increasingly in motor car engines, and the B.N.F. has been engaged in studying the foundry characteristics of the high silicon alloys that seem most suitable for such items as cylinder blocks. These materials contain upwards of 18% of silicon and special refining techniques are necessary to obtain the correct particle size of the primary silicon. The alloys have a low coefficient of expansion and, because of the high silicon content, good wear resistance. They can readily be pressure diecast to close tolerances, thus keeping machining to a minimum and their lightness should result in a better weight distribution in motor cars. Wear tests are in progress on a range of these alloys, and measurements of the long-term dimensional stability of the materials at engine operating temperatures are also in progress.

Further progress has been made in research aimed at improving the quality of gunmetal castings, and as a result of the identification of the causes of the marked variation in unsoundness with composition, a composition known as B.N.F. gunmetal has been selected as offering the optimum combination of strength, pressure tightness and soundness in heavy sections. A detailed investigation of the influence of a number of common impurities has ensured that the limits fixed in the new composition are not unnecessarily restrictive.

In modern press work, where a series of operations are carried out in line in a single machine, it is essential that the strip fed to the machine be perfectly straight if jamming in the guides is to be avoided. Most strip is rolled relatively wide and slit into narrower widths for feeding to the presses. Almost inevitably the wide strip has complex locked-up stresses which are released during slitting, causing the strip to distort. The B.N.F. roller stretcher, now in commercial production, was developed to correct these faults; it is placed between the rolling mill and the coiler and by giving a small extension to the strip it equalises the stresses so that on slitting the strip remains straight.



Meringue-type dezincification of hot-stamped alpha-beta brass fittings.

Many power and telephone cables are sheathed with lead which is extruded over the core in continuous extrusion presses. Sometimes difficulties are experienced with the operation of these presses on certain kinds of lead, frictional forces reaching such a high level that the press jams or extrusion proceeds at an uneconomically slow rate. Research is being carried out into the frictional forces developed between lead and the different types of steel used for the construction of the parts of the continuous extrusion presses.

Good agreement has been obtained between measured rolling loads and the values calculated for copper alloys from their stress-strain characteristics. This provides a useful method of calculating the optimum rolling schedule for a mill handling a wide variety of alloys, and consideration is now being given to presentation of the information in a more readily usable form and to studying its application under works conditions.

Other aspects of working and fabrication under investigation include : the tendency for adjacent turns in a coil of wire to weld together on bright annealing ; the springiness of lacquered wire which is often a source of trouble in coil winding operations ; and the directionality of ductility in high-strength aluminium alloys, which has been shown to be closely related to the soundness and structure of the original cast billet.

Corrosion and Protection

Much of the research on corrosion concerns the use of metals in domestic supply water. Difficulties have been experienced in some areas with pitting corrosion of copper water pipes, but if these pipes are thoroughly cleaned from manufacturing films they resist corrosion even in aggressive waters where there has been trouble.

The rapid blockage of hot-stamped brass pipe fittings in some areas as a result of meringue-type dezincification has been investigated, and it is now possible to predict with fair certainty from a knowledge of the composition of the water supply whether brass pipe fittings may be used without fear of blockage by corrosion products. In some instances, alternative water treatments are possible to reduce corrosion problems of this kind and trials are in progress in co-operation with certain water undertakings.

Difficulties with early failures of galvanised tanks occur in some supply waters, particularly in the Home Counties, and it has been shown that satisfactory life can be assured at little cost by using magnesium anodes to protect the galvanized steel during the first year or so after installation.

A long-standing research, during which several condenser tube alloys resistant to impingement attack were developed, has now been completed. The results of service tests on commercially made special brasses in ships and power stations in polluted estuarine waters are awaited with interest. A new research was started last September to determine the conditions which cause corrosion cracking, under static and cyclic stresses, in copper-alloy tubes used for salt and fresh water lines on ships.

The high-strength aluminium alloys are becoming increasingly important for structural applications such as bridge members and crane jibs, but some of these alloys are not completely resistant to corrosion outdoors. For example, some of the high-strength duralumin-type alloys suffer from a form of corrosion progressing from the outside to the core in layers. It has been found that this can be prevented by a simple modification to the composition of the alloy and the heat treatment. Another very effective way of protecting these high-strength alloys against corrosion is by spraying with commercial purity aluminium.

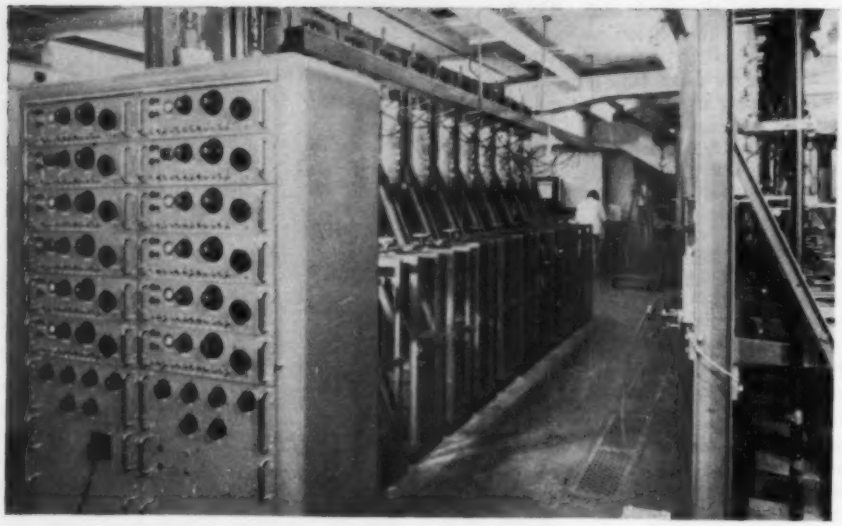
Vacuum microbalance for determining weight change of zinc specimen under oxidation.

There is an increasing interest in the use of non-ferrous metals for curtain-walling on buildings. The copper alloys, for example, would have an attractive appearance if the natural colour of the alloy could be maintained. Work is in progress for the Copper Products Development Association (an international organisation based in the United States) to develop transparent lacquers which will protect the copper alloys against tarnishing when used outdoors.

The fundamental investigation of the oxidation of zinc at high temperatures has been continued. So far a start has been made on tests on the influence of lattice orientation and impurities in the atmosphere on oxidation rate, and later the effect of impurities in the metal will be studied.

In the galvanising field work has commenced on a study of the basic factors controlling the growth of alloy layers, in order to further the progress of researches on various aspects of the subject. These include : (*a*) the galvanising in zinc-aluminium baths of hot-water system steel tanks which are in contact with aggressive natural waters ; and (*b*) the conditions favouring the application of coatings in excess of 3 oz./sq. ft. on structural steel exposed to certain atmospheres.

The major effort in the electroplating researches has been devoted to improving the durability of chromium plating, and has included a co-operative investigation with members in which the validity of several accelerated corrosion tests has been checked by comparison with the effect of atmospheric exposure on duplicate articles : this work is now nearing completion. Other work has shown that there is a progressive improvement in corrosion-resistance with increasing thickness of chromium to 0·05 thou. or more, and has also shown that there is little difference in corrosion-resistance between the coatings deposited from the several types of bath in which thicker chromium can be plated free from cracks.



Part of the new creep testing laboratory, with a control console in the foreground.

Modern electroplating solutions are extremely complex in formulation, containing various organic agents which confer brightness, smoothing power, and so on, to the deposit. The way in which these organic additions work is not at all well understood and to find out more about this, typical organic addition agents labelled with radioactive carbon or radioactive sulphur are being used to see to what extent the agents are incorporated in the deposit, how they break down in the plating solution, and so on.

Mechanical Properties

Most of the fourteen researches on the mechanical properties of non-ferrous materials have been concerned mainly with creep resistance, and include two fundamental investigations. The first of these is concerned with the behaviour of grain boundaries under creep conditions, and has shown that alloying elements can affect markedly the rate of creep at the grain boundary. In some materials, large grain boundary movements of this type are associated with the formation of intercrystalline cavities, and a new research on this aspect of creep was recently started : this is primarily intended for the nuclear energy industry, but the results will no doubt be of interest for a much wider range of industry.

Most of the creep testing equipment is designed to operate at temperatures up to 800° C., though a great deal of the work is on aluminium alloys for pressure vessels, etc., and copper-base alloys such as gunmetals and aluminium bronzes, where the temperatures involved are much lower. Researches relating creep properties to composition include those dealing with nickel-containing gunmetals; lead cable sheathing alloys ; titanium alloys ; and high temperature brazed joints. Special equipment is used for carrying out creep tests on some of the newer reactive metals such as thorium and zirconium, where, because oxidation at elevated temperatures is so rapid, the test pieces have to be strained in an atmosphere of purified argon.

A research on the fatigue properties of aluminium alloys for structural purposes has provided information useful to the design engineer on permissible stress levels in the presence or absence of stress concentrations such as notches, and on adopting ameliorative treatments to prevent fretting at joints. An investigation is also being carried out into the fatigue properties of magnesium alloys used for "canning" elements in nuclear piles. Here the test is carried out in an atmosphere of carbon dioxide at temperatures ranging from 400°–500° C.

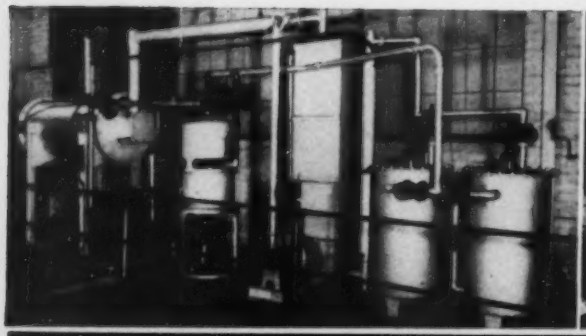
Technical Service and Information

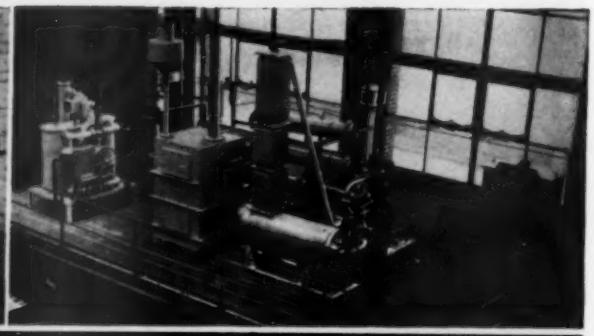
The liaison and technical service department is responsible for helping industry to exploit research results or technological advances, and in the past year has made a study of the extent to which research results could affect current technological methods, showing how the particular advance could be integrated into industrial practice, and publicising the results achieved.

A report on an investigation of air pollution arising from copper and copper alloy foundries forms the background of an advisory service to members on air pollution problems, and a study has also been made during the year of the problem of effluent disposal, particularly as it affects the copper alloy industry. A further survey—the results of which were recently published by D.S.I.R.—deals with the avoidance of wastage of nickel and chromium in the electroplating industry. This largely arises by drag-out and the survey shows how it can be recovered for re-use.

In parallel with this work the normal technical enquiry service has been maintained, to deal with members' problems on a confidential basis. Much of the work consists of "trouble shooting" in connection with production difficulties, but the examination of service failures and advice on new developments also feature largely in the work.

Where answers to technical enquiries can be obtained by reference to the literature or printed records, as distinct from those involving "know-how," they are dealt with by the information department and library, which also selects from current technical literature such items as are likely to be of value to members and lists them in the *B.N.F.M.R.A. Bulletin*, almost 4,000 appearing in 1960. Partly as a result of this, loans of particular items to members, government departments, etc., totalled more than 10,000 last year. With the increasing number of libraries operated by member firms themselves, the demands on the Association's library are often concerned with rarer material, the tracing of which sometimes requires a good deal of time and bibliographical ingenuity. This tendency may increase, with the B.N.F. library acting, from its accumulated knowledge and experience, as a bibliographical consultant.





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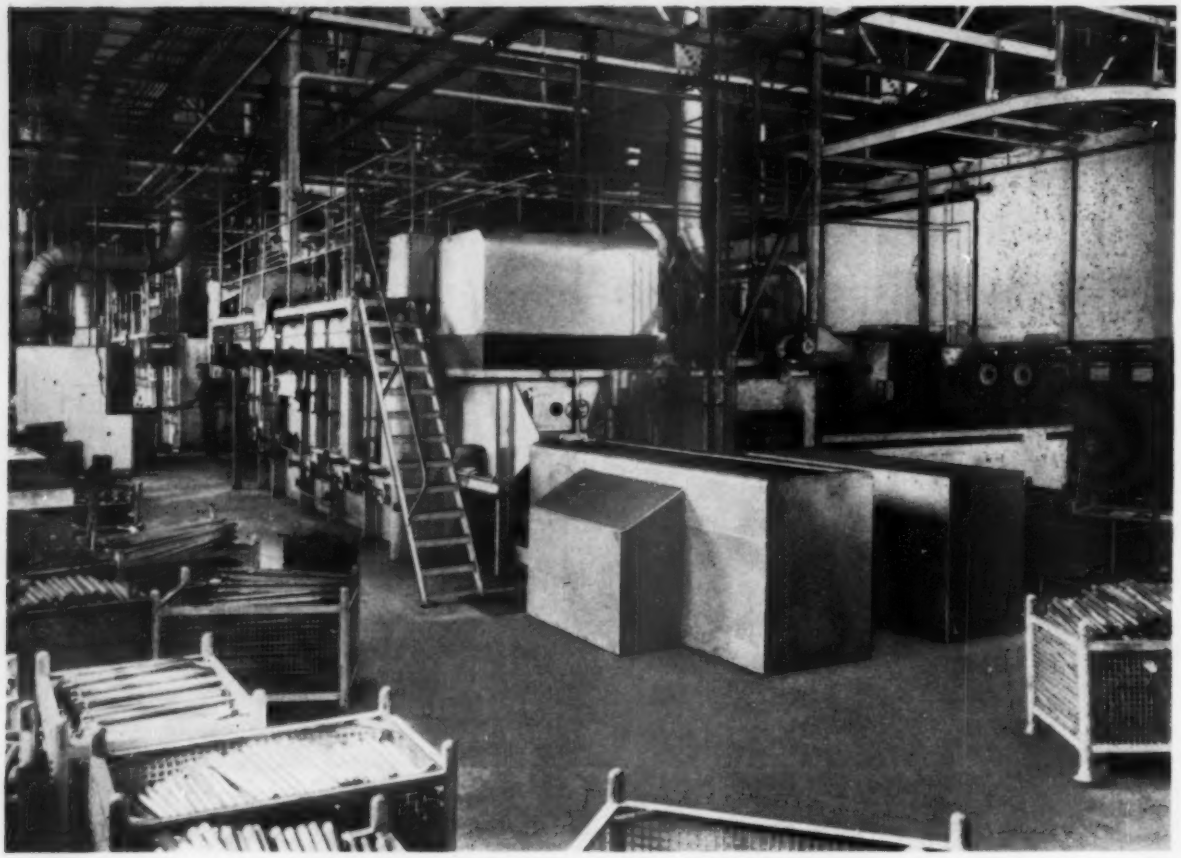

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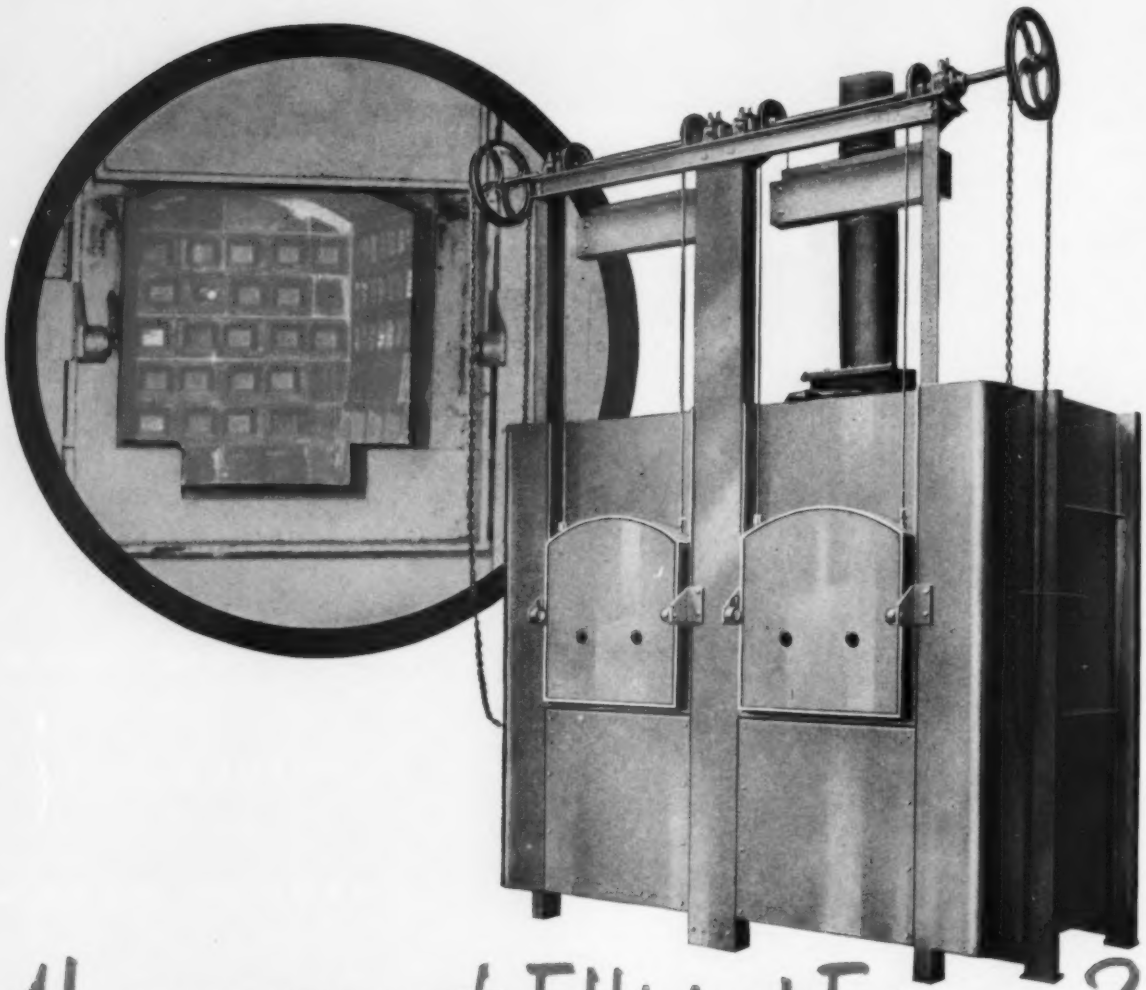

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Recent Heat Treatment Furnace Installations

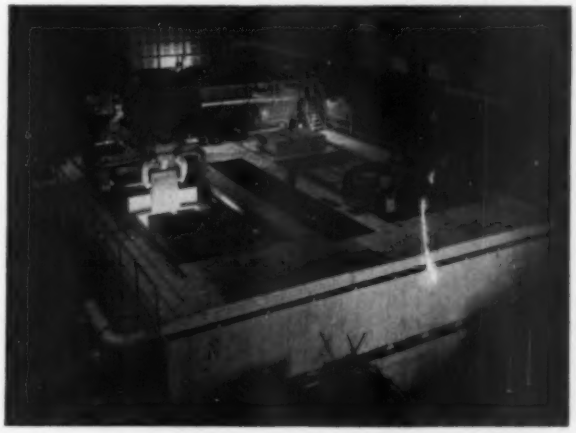
Annual Survey of Developments

Developments in the design and construction of heat treatment furnace equipment continue on a considerable scale, and over the past year many furnaces have been installed which indicate progress of a high order. The trend for larger capacity continuous furnaces for treating specialised products has continued and, while orthodox designs predominate, improvements in detail have increased their efficiency. Attention has been directed to the design of semi-continuous and batch furnaces with a view to improving their flexibility and range of temperature for general purpose work. Although necessarily incomplete, this review indicates the general trend of progress in this field.

AT one time the term " heat treatment " was mainly associated with hardening and tempering, but today it is applied to a number of processes involving the heating and cooling of solid metal, including such operations as, stress-relieving, annealing, normalising, carburising and nitriding, and in making a choice of heat treatment plant it is important to assess carefully the factors involved in the treatment contemplated. Whatever form of heat is applied, the manner in which it reaches the surface of the material or component undergoing treatment is of great importance. Closely associated are those factors which concern time and rate of heating and cooling. Ideal conditions can more nearly be approached when a furnace is to be designed for the heat treatment of mass-produced components, similar in size and design and of uniform section. Even so, the heating and cooling medium must be applied uniformly to the whole surface of each individual component, at the same temperature, at the same time, and in the same atmosphere, to produce uniformly heat treated products. Such conditions are more nearly approached with furnace units specially designed for mass production of parts involving a very precise and clearly defined treatment and output. In such cases the allowable margin to cover contingencies and unknown factors is much reduced, but a fair measure of flexibility of output and range of temperature is demanded in many types of general purpose furnace. It is important to remember that uniformly good heat treatment is not merely a matter of good intent ; it is also a question of first-class modern plant and equipment and of trained metallurgical staff. With the best will in the world—even with good staff—a good heat treatment job cannot be done without up-to-date furnaces and modern control equipment.

Reheating Furnaces

Heat treatment is not solely concerned with the final heating and cooling operations to produce the properties desired in the final product ; the process begins with the initial operation preparatory to fabricating. This initial heating has a marked influence on subsequent heat treatment and machining operations and on the results obtained in service from the finished product. In this connection reference has been made in previous reviews of the introduction of electric heating to soaking pits ; a more recent development in the heating of steel ingots and slabs is the addition of oil firing in the case of the



Courtesy of Stein & Atkinson, Ltd.

Fig. 1.—An electric soaking pit, with the addition of oil firing, for the heating of ingots and slabs.

" Elpit " electric soaking pit, shown in Fig. 1, a number of which are in operation and under construction. This design is particularly suitable for large thick pieces which are not suitable for heating in conventional soaking pits or continuous furnaces. The system can also be used for other furnaces where the advantage of fast and economic reheating with liquid or gaseous fuel can be combined with the high degree of uniformity of temperature and minimum surface contamination obtainable by electric final heating.

The oil burners are arranged above the resistor troughs with the products of combustion outlet ports at a low level. They are used to heat the charge to a predetermined temperature, when they are turned off and the waste gas flues isolated from the pits, the final heating being carried out electrically. In the event of failure of oil fuel or electricity, the whole of the heating may be carried out by the remaining heat source. Selection of heat source is available for particular applications.

A modified technique had been developed for heating alloy steel billets preparatory to forging, using a triple-chambered town's-gas fired furnace such as that shown in Fig. 2. In this design, the centre chamber is used to preheat the alloy steel billets prior to their being charged

Courtesy of Gibbons Brothers Ltd.

Fig. 2.—A triple-chambered town's-gas fired furnace for heating alloy steel billets preparatory to forging.

into higher temperature chambers arranged on either side. Waste gases from these two chambers are utilised for this preheating purpose. Both the high temperature chambers are provided with Honeywell floating temperature control and all doors are operated electrically. The billets are charged by a mobile handler with extended manipulator.

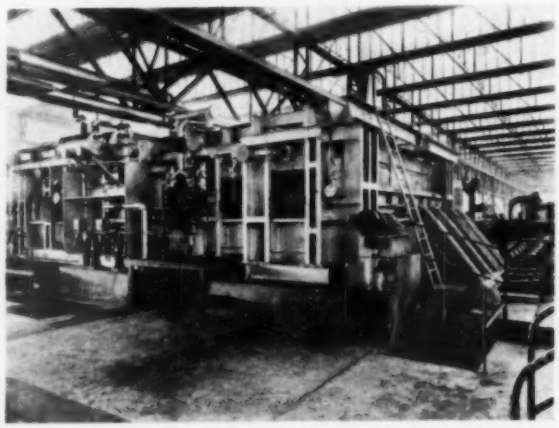
For special steels the heating requires to be particularly accurate with regard to time/temperature, oxidation control, uniformity, etc., and it is necessary to keep the product in the hottest part of the furnace for the minimum of time consistent with obtaining correct heating. With billets of differing cross section, a further problem arises in their passage through the furnace. To meet these conditions a system of moving the billets through the furnace known as the "notched hearth" system has been developed. This system is applicable to single or multi-zone fired furnaces, depending upon the capacity required, and arranged with either flat hearth or walking beam preheating sections prior to the final heating. The system consists of a series of V-notches, the billet being pushed from notch to notch by rods sliding in guides and operating through the hearth of the furnace. As the billets pass from one notch to the next they are automatically turned over, so that, each face is exposed in turn, a procedure resulting in rapid heating with the minimum of oxidation and decarburisation. In a typical example of heating in a notched hearth furnace, each face of the billet is exposed to radiation for 4½ minutes only, i.e. six periods of 45 seconds, whereas for the same output with a flat soaking hearth, the billet would remain on the hearth for 20 to 25 minutes. The furnace is claimed to be easy to run and readily adaptable to the heating curves of different grades of steel. The notched hearth section can easily be emptied whilst leaving the charge in the lower temperature preheating zone without risk of oxidation. A furnace of this type is shown in Fig. 3.

When site conditions and stock formation allow or require the charging and discharging positions of a furnace to be in close proximity, the rotary hearth furnace provides a satisfactory solution to the problem of continuous heating of billets for forging. In certain applications the same door can be used for both loading and unloading. This type of furnace can be constructed without resort to any extensive metal work in the furnace chamber, and for this reason is often preferred for high temperature processes such as heating for forging.

In an automatic machine made by Birlec-Efco (Melting), Ltd., for supplying induction heated billets to a forging press, the billets are loaded on to a conveyor and run on to platforms underneath the top path of the conveyor. These platforms lower, in sequence, the billets from the conveyor pockets on to a chute. A pusher then moves the billet for a predetermined distance into an induction heating coil of which, in this particular instance, there are three: the coils are charged in sequence. After a fixed heating time, controlled by a timer, the pusher releases the billet, which runs down the chute and discharges to the forging press. The coils are arranged at an angle to the horizontal so as to facilitate a gravity discharge and ensure emptying of the coil and the clearance of any scale.

During manufacture of leaf springs, means must be available for heating the ends of the leaves only for eye rolling etc., and a gas-fired furnace for this purpose (Fig. 4) was installed recently by Dowson & Mason, Ltd., at the Crewe works of the British Transport Commission. The furnace chamber has internal dimensions 3 ft. wide × 7 ft. 9 in. long and is capable of a throughput of 100 leaves per hour—two heats per leaf (i.e. each end of the leaf) to 1,200° C.—the leaves being at 600° C. when inserted. Each side of the furnace has fourteen entry holes for the springs, and to protect the operators from unnecessary heat, there is a radiation shield, behind which a number of air jets blow vertically upwards from the sill plate. Both sides of the furnace are identical to serve two independent gangs of operators simultaneously.

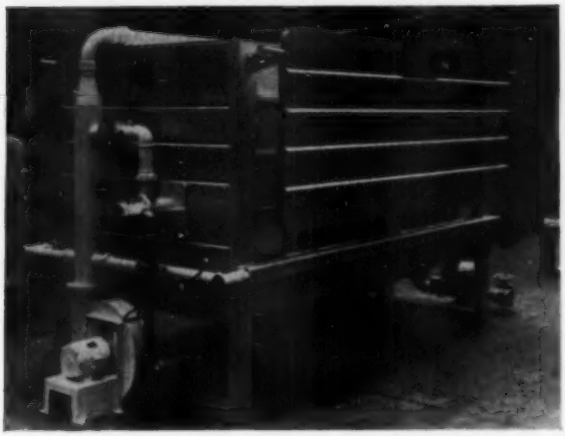
During the last few years, considerable development has taken place in the application of oil fuel, and successful experiments carried out by David Etchells (Furnaces), Ltd., have resulted in a new burner design which provides high intensity combustion. When applied to oil-burning furnaces, this burner, which is now covered by British



Courtesy of Stein & Atkinson, Ltd.

Fig. 3.—A notched hearth furnace for the heating of billets of differing cross section.

patent, operates on a two-stage type of combustion. The oil is first atomised and then volatilised before being burnt, so that it burns in exactly the same way as a gas. There is a complete and intimate mixture of fuel and air, producing a clean, hot gas. Luminosity is no longer required: in fact, furnaces operate more effectively without it. Hot spots are no longer created in furnaces. The hot gases produced pass into the work chamber and heat is transferred to the work in the furnace by convection and radiation from the walls of the chamber. As the gas has a high velocity, the excellent scouring action sweeps away the cold envelope enclosing the load. The burners prove most satisfactory with an excess of air of 2–5%, but a reducing atmosphere having $1\frac{1}{2}$–$2\frac{1}{2}$% CO can be maintained without smoke and with little luminosity. This principle of high intensity combustion has been applied to several types of heat treatment furnace, both batch and continuous, an example being the furnace shown in Fig. 5. designed for heating bars for automatic nut forging.

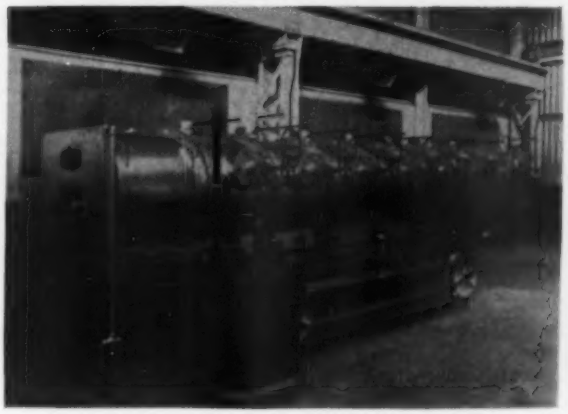


Courtesy of Dowson & Mason, Ltd.

Fig. 4.—Gas fired slot furnace installed at the Crewe works of the British Transport Commission for heating the ends of spring plates.

Fig. 6 shows a handy furnace for the heating of pipes prior to bending; it is capable of taking such pipes up to a diameter of 8 in., the heated length being 3 ft. 6 in. The furnace can be used for heating either the centre of a pipe or the ends only. The cover is counterbalanced and in two halves to assist manipulation of work pieces. The furnace is fired by town's gas and was supplied by Dowson & Mason, Ltd., to Hall, Russell & Co., Ltd., Aberdeen.

During the last few months an agreement has been reached with Granco Inc., U.S., by which AEI-Birlec, Ltd., can now offer to firms in G.B., Europe and the Commonwealth countries, the Granco gas-fired rapid billet heating furnace, which has many outstanding features. This furnace has extremely rapid contact flame heating and is built in a range of sizes for billets up to 18 in. diameter and of any length. Billet diameter can be varied widely without the need for furnace adjustment or parts change. The combination of speed and economy is particularly suited for heating light



Courtesy of David Etchells (Furnaces), Ltd.

Fig. 5.—A furnace for automatic nut forging which is heated by a new design of high intensity combustion burner.

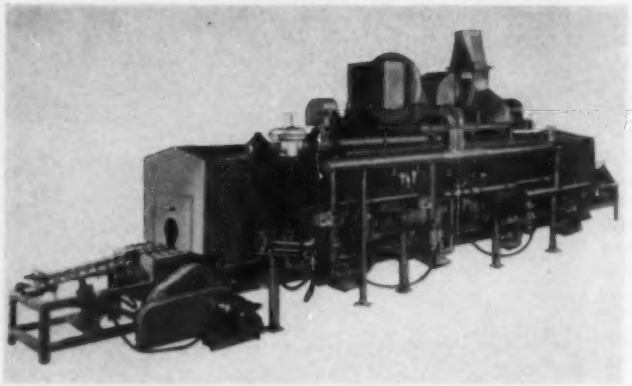
alloy extrusion billets, for which this furnace is used extensively in America. Heating rates of the order of 1 in. diameter per minute are obtained with aluminium. Incorporating electronically operated automatic temperature controlling devices, the Birlec-Granco furnace, shown in Fig. 7, is adaptable to any press; it occupies little floor space and can be equipped with automatic billet loading and transfer mechanisms to make an ideal shop layout.

Stress Relieving

Residual stresses are frequently encountered in components that have been fabricated or cast; temperature differences are the primary cause. For many purposes it is essential that these stresses be removed by mechanical or thermal treatment. In this connection, Barlow-Whitney, Ltd., have developed a range of special furnaces for carrying out thermal stability tests on high speed turbine rotors. Such rotors require most careful balancing, and it is vitally important that they remain free of any distortion when heated-up and cooled-down

Courtesy of Dowson & Mason, Ltd.

Fig. 6.—Gas fired furnace for heating pipes prior to bending.

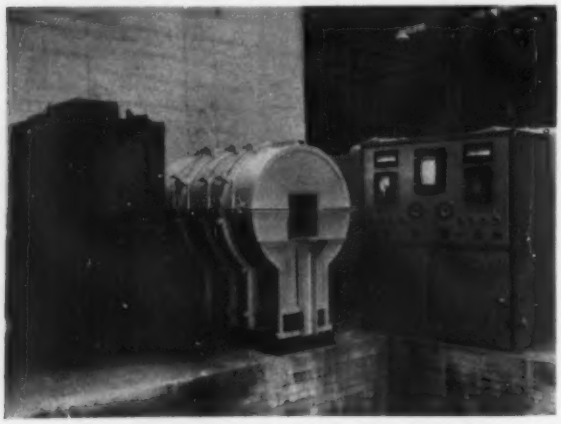


Courtesy of AEI-Birlec, Ltd.

Fig. 7.—A new Birlec-Granco gas-fired rapid billet heating furnace for billets up to 18 in. in diameter.

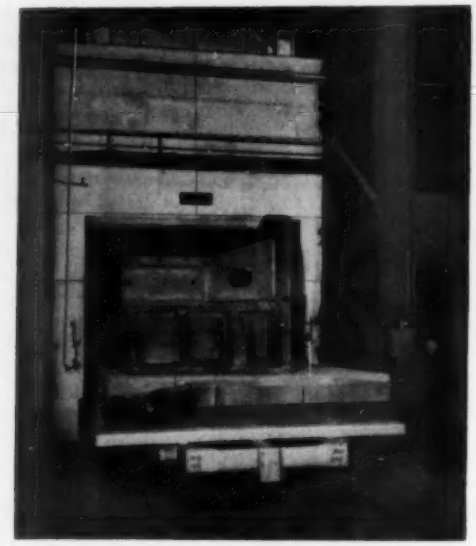
under working conditions. These furnaces enable the necessary stress-relieving operation and thermal stability tests to be carried out simultaneously. The heat treatment is carried out to a precise heating and cooling cycle, the rotor being slowly rotated and continuous measurements taken of any deformations. The furnaces are of the forced convection type with an external electric heater battery, ensuring uniform temperature up to 650° C. A feature of special interest, which will be noted in Fig. 8, is the sectional construction of the furnace chamber, the length of which may easily be varied to suit rotors of different sizes. The range covers diameters from 2 to 8 ft., with ratings of 40–200 kW.

Although welded structures have displaced many types of steel castings, the problem of residual stresses has still to be overcome, and many large furnaces have been designed and built for stress relieving. Typical of them is that shown in Fig. 9, which has recently been put into commission for dealing with large mild steel fabrications and gear blanks. Internally this furnace is 20 ft. long × 10 ft. wide × 7 ft. high. It is a bogie hearth type electric furnace and to increase the rate of heating



Courtesy of Barlow-Whitney, Ltd.

Fig. 8.—One of a series of furnaces designed for carrying out thermal stability tests on high speed turbine rotors.



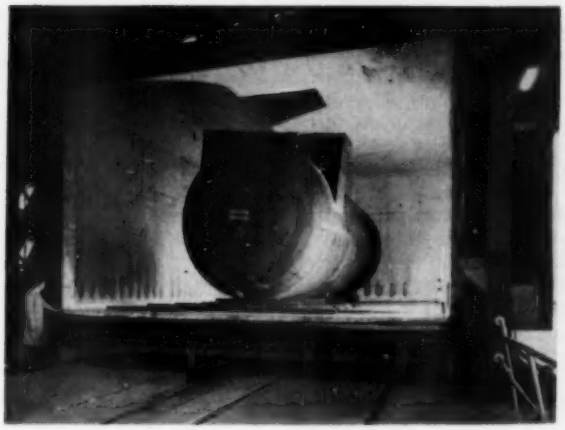
Courtesy of The General Electric Co., Ltd.

Fig. 9.—A 600 kW. bogie hearth furnace installed at the Redcar works of Dorman Long (Steel), Ltd.

and assist in maintaining a uniform temperature throughout the interior, four centrifugal-type fans are mounted in the arch roof. The furnace is rated at 600 kW., the heating elements being arranged in four separately-switched circuits with delta/star control, enabling the rating of each circuit to be reduced to one-third of its maximum. Bogie operation is by means of a motorised winch mounted in the floor of the building and controlled from a suitable point in front of the furnace. Sand sealing is adopted on the bogie.

In previous reviews we have referred to Dowson & Mason, Ltd., as designers and builders of large bogie hearth furnaces. An interesting example is the stress relieving furnace recently installed at the Dalmuir Works of Babcock and Wilcox, Ltd., and shown in Fig. 10. This furnace is 28 ft. wide × 15 ft. high × 32 ft. long, and the bogie is designed to take a load of 100 tons. Firing is by town's gas, and to obtain close uniformity of temperature in a chamber of this size, burners are placed in the rear wall and across the front of the bogie in addition to those in the side walls. The flat roof is suspended and the door is cross-traversing, suspended from an overhead gantry, and electrically operated. There are multiple small flue ports in the surface of the hearth, connecting with collecting flues formed in the hearth brickwork which run longitudinally backwards to the rear wall of the furnace, where they communicate with a main flue and chimney system. This design was adopted to obtain uniform temperature conditions in the large fabricated mild steel rings for which the furnace was primarily required, but outsize furnaces of this type are expected to cope with a variety of components and products as, for example, the pressure vessel shown in the illustration.

Thermic Equipment and Engineering Co., Ltd., are now manufacturing the newly developed and patented Thermic-Schoppe combustion chambers for use in all



Courtesy of Dowson & Mason, Ltd.

Fig. 10.—An outsize stress relieving furnace installed at the Dalmuir works of Babcock & Wilcox, Ltd.

Courtesy of Thermic Equipment & Engineering Co., Ltd.

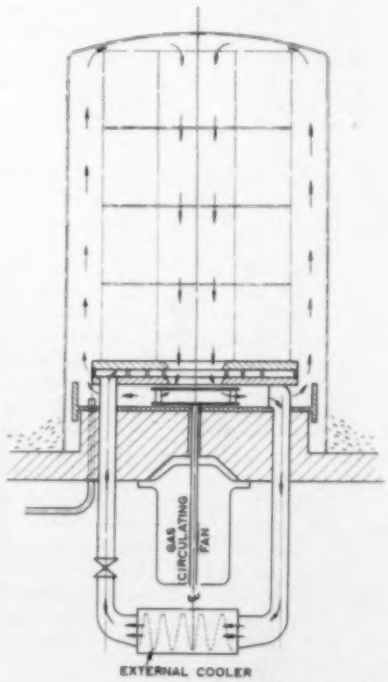
Fig. 11.—A stress relieving furnace incorporating the newly developed and patented Thermic-Schoppe combustion chambers.

types of heating appliances, both oil and gas fired. Fig. 11 shows a stress relieving furnace in which they are used. It is a continuous oil fired furnace having conventional slat conveyor chains for moving high quality castings through the furnace. The combustion chambers have been applied as though they were town's gas burners, that is at intervals along the side of the furnace, firing through burner ports in the side walls. The products of combustion enter the furnace chamber upwards behind a guard wall and are drawn down through the work and conveyor to flues arranged in the centre of the hearth. Not less than 85% of combustion takes place inside the Thermic-Schoppe combustion chamber, the product of combustion containing not more than 5% excess air. The combustion chambers are fitted with spill-over type air atomised medium pressure oil guns, to give accurate single point proportional control of multiple combustion chambers and a turn down of 10 : 1 for the " stand-by " condition. With the aid of this controlling system and the combustion chambers, the furnace atmosphere is kept at a constant analysis and uniform temperature.

Annealing and Normalising

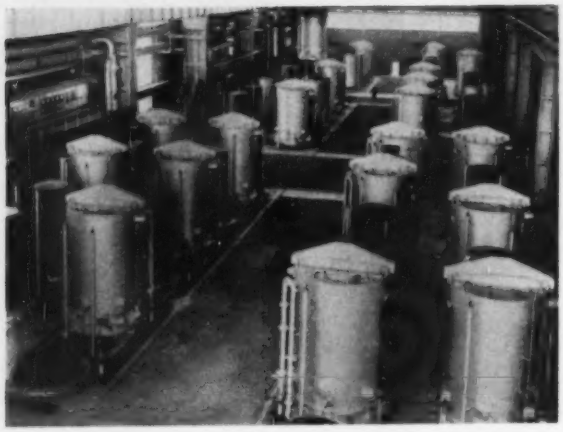
The annealing operation consists in heating the material to some predetermined temperature, holding the temperature constant at the predetermined point for a given length of time, and cooling at a predetermined rate to atmospheric temperature. There may be one or more of several objectives involving annealing, but, mainly, its purpose is to modify the structure of the material to facilitate fabrication. Many types of furnace have been designed for this form of heat treatment and developments in their design are frequent. In batch annealing of tinplate and sheet coils, for instance, a large part of the total cycle time is taken up by the cooling period, in which the coils are cooled from their annealing temperature to a temperature low enough for them to be exposed to the atmosphere without impairing the surface appearance. In collaboration with the Steel Company of Wales, Ltd., Salem-Brosius (England), Ltd., have installed equipment to reduce the cooling period and this development is the subject of a patent held by the Steel Company of Wales, Ltd.

Investigations have shown that, on a multi-stack large capacity base, the cooling time is determined by the temperature of the bottom coil. A method has been devised for accelerating the cooling of these multi-stack units by the cooling and recirculation of the protective atmosphere gas during the cooling cycle, and a number of bases have been installed and operated successfully for some time. The basic design of the system is shown in Fig. 12, an important feature being that no auxiliary



Courtesy of Salem-Brosius (England), Ltd.

Fig. 12.—Showing the system developed for reducing the cooling period in the batch annealing of tinplate and sheet coils.



Courtesy of Salem-Brosius (England), Ltd.

Fig. 13.—A typical single-stack direct-fired annealing plant.

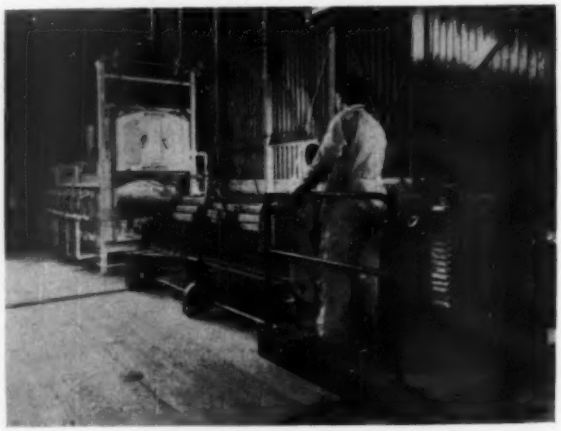
fans are required. The normal base fan circulates a proportion of the protective atmosphere gas through an external cooler, from which it re-enters the hearth on which the coils are stacked. During the heating and soaking periods a valve in the cooling circuit is closed, thus preventing the cooling of any of the atmosphere gas in circulation around the coils. From such multi-stack accelerated cooling bases now in operation, the cooling time has been reduced to below that of the combined heating and soaking time, and the bottom coil has cooled as fast as the top coils. The great merit in using these accelerated cooling bases is that the size of the building necessary for a large tonnage batch annealing plant, using fixed bases and portable cover type furnaces, would be much reduced for a similar output and, consequently, for a new installation, there would be a saving in capital costs.

It is still normal practice in batch annealing to use sand or similar material as a sealing medium for the inner covers, although liquid seals have been used to obviate the hazard of sand or dust on the coils, due to the re-circulation of the atmosphere gas inside these inner covers and around the coils. The sealing now being installed in the Salem/Ludwig single stack units can be regarded as a major development, since it can be termed a mechanical seal, no separate sealing medium, such as sand or liquid, being used. The adoption of this seal has eliminated the possibility of any trouble due to contamination of the atmosphere, or due to sand or dust, when high-powered atmosphere gas recirculating fans are used ; a further advantage in the use of this type of seal is a reduction in the consumption of protective atmosphere gas needed, particularly when annealing cleaned plate. The first large tonnage annealing plant in Britain, consisting entirely of single stack furnaces, is now being built by Salem-Brosius (England), Ltd., in conjunction with Ludwig, Essen. The furnaces are direct-fired and incorporate air recuperation with a resultant reduction in fuel consumption. Fig. 13 shows part of a typical single stack annealing plant.

A commercial method for changing and controlling the composition of steel is the direct outgrowth of the relatively new open coil annealing process. Developed by the Lee Wilson Engineering Co., Inc., Cleveland, the new method makes it feasible to remove or add carbon, nitrogen and other alloying elements that can be gasified during the annealing of commercial-size coils of rolled steel. It is known as the Lee Wilson open-coil process of gas alloying, for which the Incandescent Heat Co., Ltd., is the British Licensee.

It may be noted here that Incandescent sheet annealing division is supplying fifteen 4-stack furnaces and fifteen single-stack furnaces and a total of seventy-two bases to handle 17,000 tons per week of steel in coils up to 84 in. diameter, stacking height 180 in., at the new Richard Thomas & Baldwins' Spencer Works, Llanwern, nr. Newport. All these furnaces incorporate waste heat recovery.

John Mathison, Ltd., have recently installed at the Coatbridge roll foundry of R. B. Tennent, Ltd., a gas-fired portable cover furnace with internal dimensions 30 ft. long × 12 ft. wide × 7 ft. high and with a hearth capable of being loaded up to 100 tons. The maximum temperature is 1,100° C., and tests taken on the load during soaking show a maximum variation of ±5° C. The furnace is designed so as to impart heat both under and over, as well as along either side of the charge, the combustion arrangements being such as to avoid flame impingement. Preheated air and gas are intimately mixed in a venturi throat at high velocity and from thence reduced in velocity into a special high alumina refractory burner quarl. The vertical flames which impart heat to either side of the charge are developed in rectangular slots along the hearth, whilst the horizontal flames are directioned through restricted orifice burner quarls. A multiplicity of counterflow recuperators is used for preheating the air for combustion and ensuring sound fuel economics. The combustion products are exhausted from the waste gas flues under the refractory base to waste gas stacks which link up with the outside of the building. The pressure inside the furnace is controlled by a regulator operating on the waste gas damper. Safety devices are fitted to cope with failures of gas or air, or with electrical or mechanical failure likely to result in air failure.

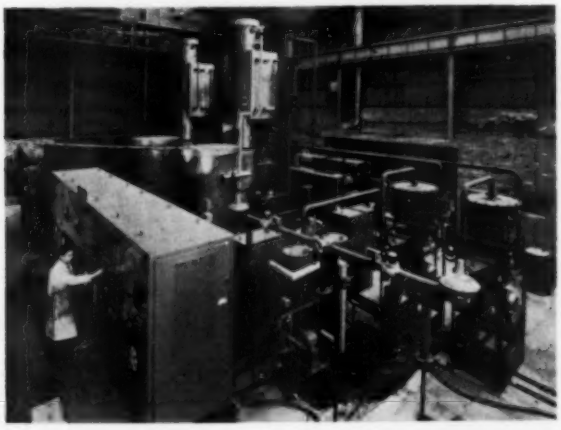


Courtesy of Brayshaw Furnaces Ltd.

Fig. 14.—Bar annealing furnace at Gillot's Forge and Rolling Mills, Ltd., with electric charging machine in operation.

Roll treatment calls for programme control of the temperature, involving as it does an extremely slow rise in temperature from cold, with accurately controlled intermediate soaking periods, carefully regulated rise in temperature through the critical ranges, followed by equalising treatments, then a more rapid rise in temperature up to the desired final temperature. Automatic pyrometric control gear is fitted, the burners being grouped in three zones, each having its own recording controller, the latter being regulated by means of a master programme controller. Each zone is regulated from its own master valves, both air and gas. A by-pass arrangement for air and gas is also fitted so as to maintain the flame from the minimum to the maximum rate of fuel consumption.

In a charger hearth type furnace for bar annealing in the temperature range 500° –1,000° C.—designed to heat a load of 5 tons to 850° C. in approximately 5½ hours from cold—Brayshaw gas and air blast self-proportioning single-lever Venturi-type burners situated along each side of the furnace fire into the work chamber immediately beneath the arch to avoid flame impingement on the work, and also under the hearth to provide bottom heat to the load. The burners are arranged in three zones for automatic temperature control by Electroflo instrumentation which includes programme control and recording equipment.



Courtesy of AEI-Birlec, Ltd.

Fig. 15.—A nitrogen generator for India to produce atmosphere for bright annealing furnaces.

The furnace (Fig. 14) is loaded by an electric two-arm charging machine arranged for forward, reverse and traversing movement. Hard quality firebrick is used for the furnace hearth and charger piers, the arms of the machine running on heat resisting steel flats. The furnace lining comprises hot-face refractory insulation backed by firebrick and designed for a normal 24 hour heating and cooling cycle.

A number of items of Birlec equipment has been ordered for operation in India. They are of a special nature and include a bell furnace, a roller hearth furnace, a nitrogen generator, and adsorption and refrigeration dryers. The roller hearth furnace, which is for annealing steel strip in coils or lengths, has a maximum output of 2 tons per hour when annealing coils at the temperature of 680°—700° C. It will accept coils up to 4 ft. diameter and is rated at 525 kW., divided into five zones. Zone 1, rated at 185 kW., is supplied through a step-down transformer for cast grid elements; the remaining zones have tape elements on mains voltage. The bell furnace has three hearths, each being provided with a cylindrical bell-shaped cover fabricated from nickel-chrome alloy sheet.

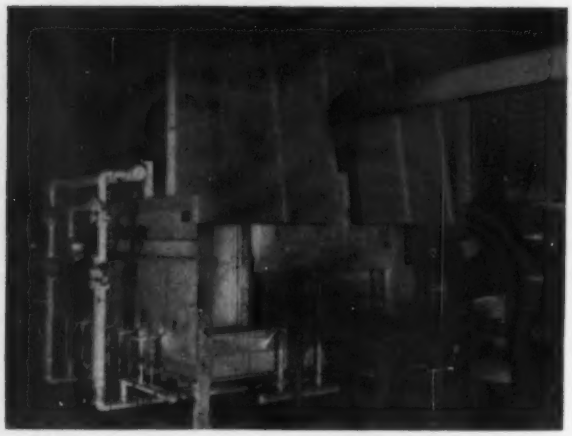
Courtesy of G.W.B. Furnaces, Ltd.

Fig. 16.—A large flash annealing furnace for sheet up to 8 ft. wide.

The nitrogen generator for this plant, has an output of 3,000 cu. ft./hr., the gas, which is derived from a kerosene/air mixture, being delivered to the furnace at a very low dewpoint. The atmosphere plant, shown in Fig. 15 operates on the cycle of mix, partly burn, cool, demist, and refrigerate, the resulting atmosphere being used in the bright annealing process.

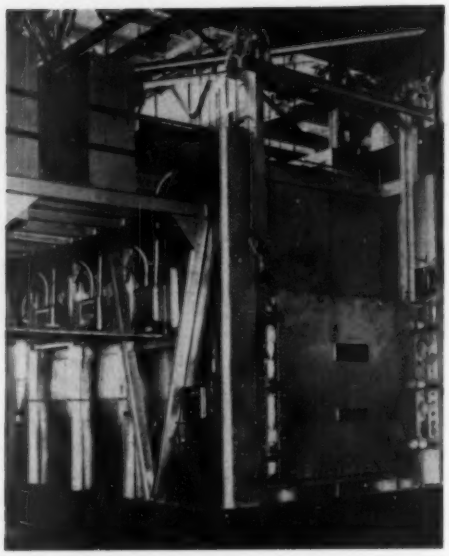
A flash annealing furnace which will take sheet up to 8 ft. wide, working in conjunction with a new strip mill devoted to the rolling of aluminium alloys, has recently been installed at the Quinton Woodgate Works of Birmetals, Ltd. This Sendzimir mill, the first of its type to be used for this purpose in Europe, rolls the alloy in strip form at 1,600 ft./min. The furnace equipment designed and manufactured by G.W.B. Furnaces, Ltd., has four working zones totalling 600 kW. During the early commissioning stages of this furnace, extensive tests were carried out to ensure the maximum uniformity of material heating across the width. Eight patent centrifugal fan units are mounted on one side of the furnace chamber, and these, working with the requisite system of air directing baffles, provide the charge with an evenly distributed flow of hot air.

The production of aluminium alloy articles involving a pressing operation inevitably brings in the question of the grain size of the metal of which the items are composed. Generally, the smaller the grain size, the better the deep drawing properties of the material and the quality obtainable on the final product. The continuous flash annealing process is ideal for this purpose, heating the material to the required temperature in the shortest possible time and ensuring, as far as is possible, that the whole charge passes through the same temperature cycle. The present furnace, a general view of which is shown in



Courtesy of Brayshaw Furnaces, Ltd.

Fig. 17.—A gas-fired controlled atmosphere muffle furnace installed for the normalising of low-alloy steel sheets.



Courtesy of Stordy Engineering, Ltd.

Fig. 18.—One of two stain-free annealing furnaces installed in a large aluminium works in Canada.

Fig. 16, has the following effective dimensions : loading length 6 ft., heating chamber 40 ft., cooling chamber 70 ft., unloading table 6 ft., and a width of 8 ft. 6 in. It was designed to give a nominal throughput of 2 tons per hour, although figures far in excess of this have, in fact, been achieved.

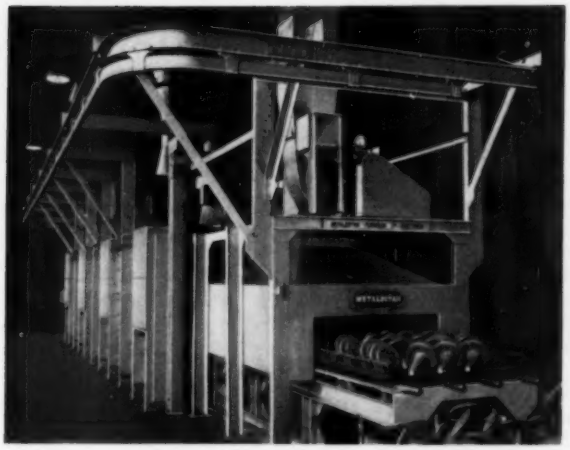
A gas-fired controlled atmosphere muffle furnace has been installed for normalising low-alloy steel sheets, ranging from 12 to 22 s.w.g. It is designed to operate in the temperature range 650°–1,000° C. and is of the underfired type, complete with exothermic furnace atmosphere generator capable of producing 2,000 cu. ft./hr. The muffle, 4 ft. wide × 10 ft. 6 in. long, is of sillimanite backed to the furnace casing by refractory insulation to reduce heat losses to a minimum. Heating is effected by burners of the Brayshaw wide-range nozzle-mixing design, firing alternately from each side of the furnace and under the hearth, the products of combustion passing up the side walls and round the muffle before being exhausted to atmosphere. The burners are suitable for consuming town's gas in conjunction with air at a pressure of 18 in. w.g. This furnace, shown in Fig. 17, has a maximum gas consumption of 2,500 cu. ft./hr., and will maintain an output of 800 lb. of sheets at a temperature of 970° C. on approximately 1,900 cu. ft./hr. The furnace is automatically controlled in two zones by Electroflo indicating and controlling three-position instruments operating in conjunction with gas and air proportioning equipment.

True bright annealing has always been difficult for producers of stainless steels and other chromium-containing alloys. Acceptable results have been obtainable in certain cases—wire and narrow, thin strip—by heating in a muffle purged with very pure hydrogen or nitrogen-hydrogen mixtures. This practice has the severe limitation of recurrent muffle repair or replacement costs, and satisfactory muffles have not been available for any but narrow furnaces. Within these limitations several Birlec furnaces have been installed for this work during the past twenty years, but development of improved designs has been actively pursued in the research department of AEI-Birlec, Ltd., which has resulted in a new design of furnace needing no muffle ; a prototype to this design has now been in operation for several months with highly satisfactory results.

Based on the use of a special type of refractory for the lining, this new furnace breaks through the limitations of the muffle type in several respects. The electric heating elements radiate directly on to the work, without the intervening obstacle of the muffle wall, and therefore permit higher heat inputs and higher work temperatures than could be safely used in the old design. Means for conveying the material through the furnace are no longer limited to those which could be contained within a muffle. Furnace chamber size and shape is similarly freed from restrictions imposed by muffle design. The design is based on the continuous passage of the material, because of the time required to establish in the work chamber a protective gas atmosphere of sufficient purity to give truly non-oxidising conditions.

This furnace, in its prototype form, is designed for the continuous bright annealing of strip which passes horizontally through the consecutive heating and cooling chambers. Special gas seals at the ends reduce the loss of atmosphere gas (cracked ammonia or hydrogen) to a minimum and rollers support the moving strip. A vertical version of the furnace is available for dealing with highly finished strip which must not come into contact with rollers or other supports while heated, but the horizontal type is adaptable to handle tubes or other forms of material on a moving belt or roller conveyor.

The increasing demand for a bright, stain-free end product has caused a close study of the probable causes of staining, etc., of aluminium stock, and the recent tendency has been to anneal under inert atmosphere conditions. The annealing operation is normally through a temperature range of 350°–450° C., and the furnace shown in Fig. 18 is one of a number installed by Sturdy Engineering, Ltd., designed not only to attain close



Courtesy of Garringtons, Ltd.

Fig. 19.—One of several continuous pusher type furnaces by Metalectric Furnaces, Ltd., employing apron type alloy trays for carrying the components.

temperature control, but to carry out the treatment under suitable atmosphere conditions. The illustration shows one of two furnaces installed in a large aluminium works in Canada, which has been in production operation since last September and has more than satisfied the very stringent conditions laid down at the time of ordering.

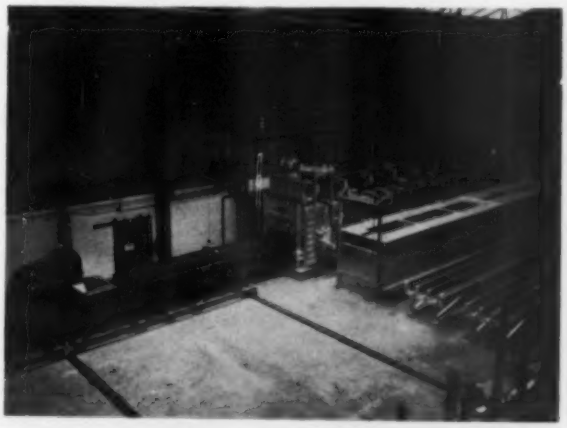
The furnace has a working length of 15 ft., a width of 7 ft 6 in. and a height of 6 ft. 9 in., and is fitted with three large volume axial flow high temperature circulating fans, situated in the roof of the furnace. The total volume handled by the three fans is in excess of 100,000 cu. ft. of air per minute, so that a highly turbulent condition exists over the whole of the work space. Arranged for electric heating, this furnace has a total connected heater load of 900 kW., the heater banks being suitably sub-divided and, by means of the selector switches incorporated in the contactor gear, enabling close temperature control to be achieved without sacrificing fast heating-up rates. It is capable of handling charge loads of the order of 40,000 lb. of aluminium at one time.

The method of loading is by means of an existing charging machine of the three-arm pattern, and the hearth design avoids any refractory, thus maintaining clean, dust-free working conditions. The door sealing frame is water cooled and an adjustable asbestos primary seal (also water cooled) and a pneumatic clamping gear of the cam-operated pattern, have been provided, the door itself being motorised and counterbalanced.

Fig. 19 shows one of several electrically heated continuous pusher type furnaces recently installed, having a throughput of 25 cwt./hr. An interesting feature are the apron type special alloy trays used for carrying the components, these being pushed along rails running through the installation and matching together to form an unbroken conveyor line. By this method very high loading densities are achieved when operating at normalising temperatures. Progress of the trays through the furnace is established by an automatic, timer-controlled, sequence-operated, hydraulic pusher system and, after discharging, the trays are simply returned to the charging end by overhead mono-rail conveyor. Other notable features are removable hearth heating elements, scale removal pockets, and a forced cooling section at the discharge end. For cycle annealing, cooling equipment is embodied in the furnace structure. This furnace is of the multi-zone type and the connected rating is 550 kW.

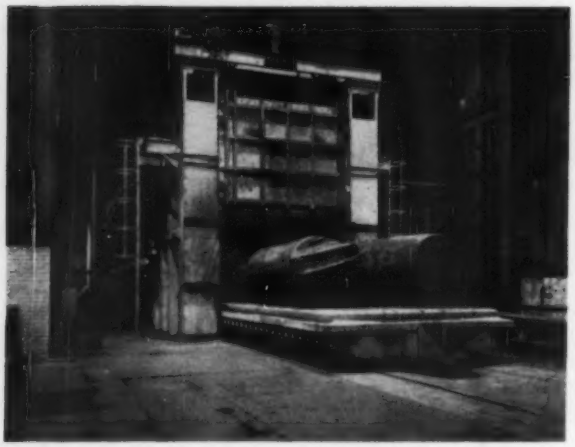
An installation which forms part of the expansion programme at the Bromford Works of Stewarts and Lloyds, Ltd., is shown in Fig. 20. It is designed for the heat treatment of tubes and has an electrical rating of 1,000 kW. and a maximum operating temperature of 1,000° C. : it is capable of accepting a 15 ton charge of tubes having a maximum length of 50 ft. There are five separate heating zones along the length of the furnace chamber and powerful air circulation fans are mounted in the heating chamber roof. To cover the wide range of critical cooling speeds of the various tube steels, furnace cooling with or without protective atmosphere, charging machine air-blast cooling, and a cooling chamber capable of accelerated or retarded cooling, are all provided. The necessary protective atmosphere is available from a generator which produces nitrogen by the combustion of town's gas and air, subsequent removal of both carbon dioxide and water vapour giving an atmosphere containing approximately 99% pure nitrogen.

Fig. 21 illustrates the larger of two bogie hearth gas fired recirculation type furnaces recently installed at the Parkhead Steel Works of William Beardmore & Co., Ltd., for the treatment of large steel forgings and castings at temperatures between 150° and 950° C. The bogie has a nominal working area 12 ft. wide × 50 ft. long, with a loading capacity of 250 tons. High velocity recirculation of the products of combustion is used as the heating system, the furnace being divided into six separate zones, each with its own combustion chamber and recirculating fan unit mounted on top of the furnace. This system ensures rapid and even heating and heat distribution within a very low tolerance. The combustion system is fully safeguarded by electronic flame failure equipment on the main and pilot assemblies together with a pressure air failure device. Control of the furnace temperature is effected by Honeywell automatic temperature and pressure control instrumentation.



Courtesy of Stewarts and Lloyds, Ltd.

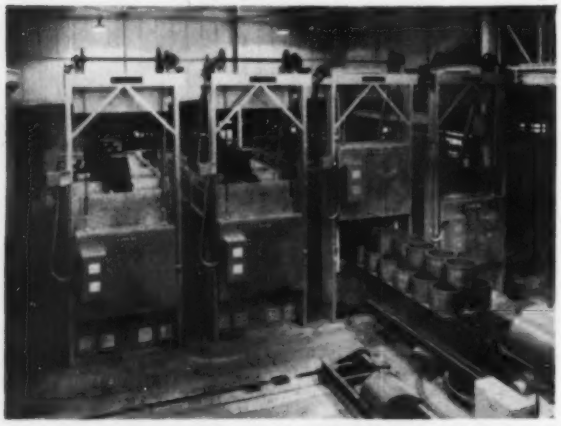
Fig. 20.—Designed by Metalectric Furnaces, Ltd., for the treatment of tubes, this furnace will accept a 15-ton charge with a maximum length of 50 ft.



Courtesy of Brayshaw Furnaces, Ltd.

Fig. 21.—The larger of two bogie hearth furnaces for the treatment of large steel forgings and castings.

As part of a development project at the works of Earle, Bourne & Co., Ltd., four electric batch furnaces have been put into commission during the last few months for annealing brass strip. In addition to the furnaces, which are shown in Fig. 22, the installation includes a heavy duty steelworks-type turntable charging machine of Gibbons-van-Marle design and five loading tables. Each furnace is 20 ft. long × 5 ft. wide × 3 ft. 9 in. high to the crown of the door opening. Each is rated at 342 kW. in three zones, and is designed for operating up to a maximum temperature of 750° C. Two of the furnaces are equipped with reduced rating input control, so that they may operate, with close temperature uniformity, at lower temperatures for charges requiring stress relieving. Five waffler type air circulating fans are fitted in the roof of each chamber, use being made of an independent motor drive. The electrical equipment to each furnace comprises a switchgear cubicle working in conjunction with an Ellison oil-immersed circuit breaker, and the temperature control



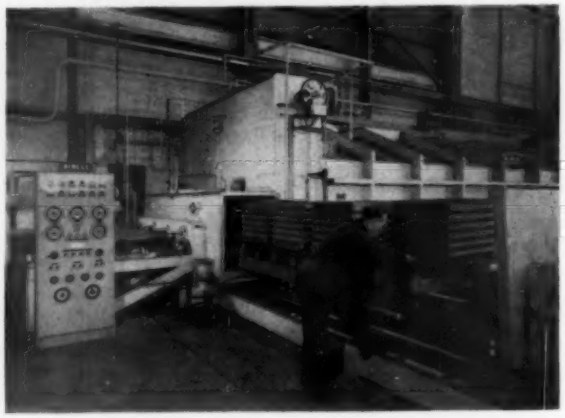
Courtesy of G.W.B. Furnaces, Ltd.

Fig. 22.—Brass strip coils being withdrawn from one of four batch furnaces recently installed at Earle, Bourne & Co., Ltd.

is by three Electroflo indicating controllers and an Electroflo three-point recorder. Safety contacts are fitted to these recorders so that the main electric supply is cut off automatically in the event of accidental overheating, so isolating the furnace. At present these furnaces are working 24 hours-a-day.

New annealing equipment has been installed by Ley's Malleable Castings Co., Ltd., for the treatment of pearlitic blackheart malleable castings, for which there is a growing demand in the automobile and allied industries. It is a continuous equipment with a minimum capacity of 150 tons per week ; continuous equipment was decided upon to obtain the very fast and uniform cooling required after the high temperature part of the annealing cycle to provide high quality products.

The plant comprises a furnace for the high temperature treatment, followed by a charge dumper and air blast cooling conveyor and, finally, a low temperature furnace with cooling station and tray discharge gear. Conveyors are included for returning the trays to the charging areas. The furnaces are of the pusher tray design with hydraulic



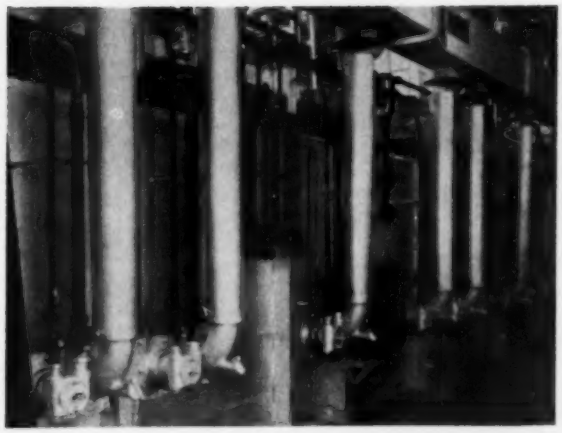
Courtesy of AEI-Birlec, Ltd.

Fig. 23.—Charge end of multi-track high temperature furnace of installation for the treatment of pearlitic blackheart malleable castings.

operation and automatic sequencing throughout, the complete plant being operated by two men only, with the necessary occasional supervision of the heat treatment superintendent and laboratory personnel. The charge end of the multi-track high temperature furnace is shown in Fig. 23. It is noteworthy that this plant has now been operating under normal conditions for almost a year, from which it is clear that the chief aims, in quality of castings produced and reliability in service, have been achieved.

Carburising

Among the recent developments associated with carburising and carbonitriding furnaces, is that of a carbon potential controller, which has been developed by G.E.C. in conjunction with the Infra Red Development Co., Ltd. This controller will automatically adjust the carbon potential of the atmosphere of a carburising or other heat treatment furnace so that it is in equilibrium with any steel having a carbon content between 0·3 and 1·2%. It is not only suitable for a new installation, but



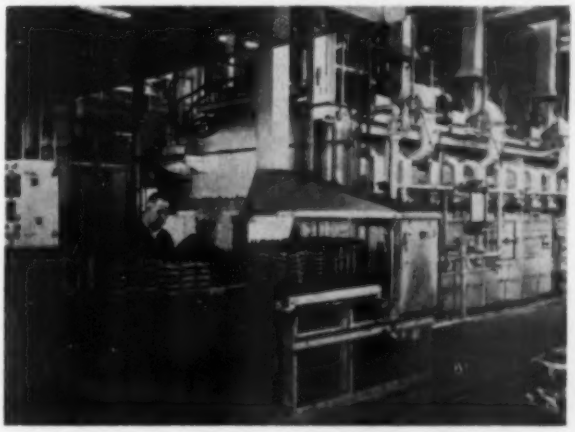
Courtesy of International Furnace Equipment Co., Ltd.

Fig. 24.—Close-up of radiant-tube-heated gas carburising furnace.

can easily be fitted to an existing furnace. In this case a gas probe and a filter are mounted on the furnace and a switch is linked with the lid of the furnace or to a circuit operated from the existing lid switch. The rest of the control gear is built into a steel cubicle.

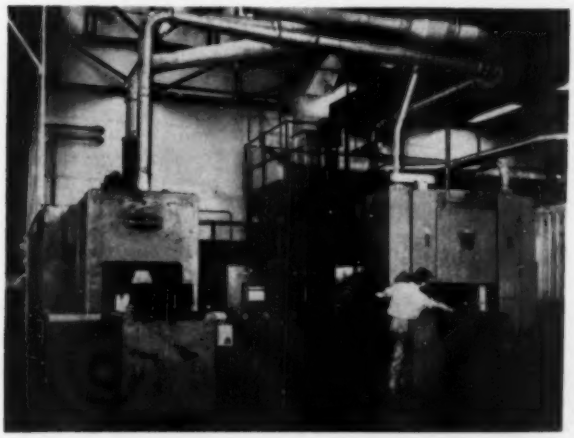
Operation of the carbon potential controller is based on the continuous analysis of the CO_2 content of the gas from the furnace. This is measured by an infra-red analyser, the output of which is fed to a central unit, which operates a motorised valve controlling the addition of the enriching substance. The process is controlled by a programme unit which, for carburising, provides for three stages: preheating, carburising and diffusing. During the preheating, no carbon-rich gas (or only a small amount) is added to the furnace; during the carburising period, the atmosphere is controlled to a carbon potential preset on a dial, and during the diffusing period the atmosphere is adjusted to another carbon potential on a second dial. At the end of the process, visible (or audible) warning is given to the furnace operator. The duration of the various periods is adjustable by time dials.

In controlled atmosphere furnaces for gas carburising, carbonitriding, malleable annealing etc., the work is enveloped in a mixture of active and diluent gases in a gastight chamber. To maintain control of the furnace atmosphere as required for desired results, the work chamber must be kept free from products of combustion when oil or gas heating is used. In the case of electrical heating it is often necessary to keep the heating elements out of contact with the furnace atmosphere. The use of muffle type construction is unduly expensive in the case of large furnaces and this situation led to the development of radiant tube heating. In this method, the heating medium is itself enclosed in small tubes or muffles which are inserted in the furnace chamber. Tubes may be heated by gas, oil, or electricity. Fig. 24 shows a close-up of a radiant-tube-heated gas carburising furnace, one example of the wide range of heat treatment plant manufactured by the International Furnace Equipment Co., Ltd. In the event of tube failure, the individual tube can be quickly replaced from outside the furnace.



Courtesy of British Furnaces, Ltd.

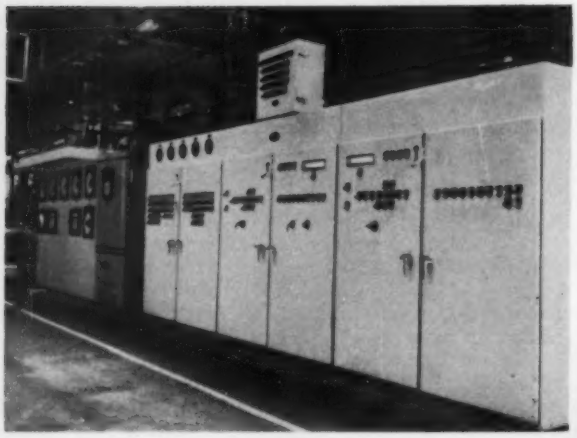
Fig. 26.—Recently commissioned, this continuous carburising furnace is the fifth of its type to be supplied to Vauxhall Motors, Ltd.



Courtesy of Ford Motor Co., Ltd.

Fig. 25.—Hardening and tempering plant by Metalectric Furnaces, Ltd., with a sealed quench furnace for hardening.

A new system, which incorporates open type electric heating elements, has been developed by Metalectric Furnaces, Ltd., for use in carburising atmospheres. These elements, working on a low voltage, have a special coating which enables them to withstand the carburising action of the furnace atmosphere. Their use facilitates a high electrical rating as compared with the previously accepted elements contained in radiant tubes. A vital factor is the extremely fast heating time in comparison with similar size gas-fired furnaces and, particularly with short cycle carbonitriding, a much greater throughput for a given furnace volume. The sealed quench furnace shown in Fig. 25 is designed on this system, known as the Unicarb system. It has a connected rating of 71 kW. and the usable dimensions are 3 ft. 6 in. long × 2 ft. 3 in. wide × 1 ft. 3 in. high. The quenching and charge and discharge mechanisms are fully automatic and the plant is complete with endothermic generator and propane and ammonia additive equipment.



Courtesy of British Furnaces, Ltd.

Fig. 27.—Temperature control and sequence control panels for the Vauxhall continuous gas carburising furnace.

The continuous gas carburising furnace, recently commissioned and shown in Fig. 26, is the fifth plant of this type to be supplied to Vauxhall Motors, Ltd., and is unique in that it is virtually two independent single track furnaces in one common shell. This is an advantage, since it can be used for treating any other type of component where necessary, without interfering with its main purpose, which is to provide full capacity for passenger vehicle rear axles and gear box components. The furnace is wholly automatic in operation and two or three men can operate the whole plant, which is equipped with a vast electronic control panel, incorporating safety interlocks, the whole being so designed that every stage of the operation can be observed.

The heating, carburising and diffusion zones are heated by a number of British Furnaces suction-type radiant tube burners using clean and cool producer gas. These burners are grouped into five automatic temperature-controlled zones, and a special feature is the close control of the combustion-air gas ratio obtained by the use of two exhaust fans and proportioning equipment on each zone. Endothermic carrier gas and enrichment propane are supplied in correct proportions to the different zones, and adequate atmosphere circulation is obtained by the use of high powered air cooled fans. The endothermic gas is piped from a ring main system introduced by Vauxhall Motors a few years ago.

A slot door is incorporated in the rear wall of the furnace, at the discharge end of each track, for the individual removal of components which require to be press quenched. In addition, a side discharge door is provided for each track leading into an enclosed vestibule mounted above a sealed oil quench tank, where the components and trays are mass quenched. After being carburised and quenched, the components are passed through a small oil blow-off chamber, in order to remove surplus oil, prior to entering a washing machine, followed by a tempering furnace.

Where a wide range of heat treatment requirements render the use of continuous gas carburising equipment uneconomic, the sealed quench batch furnace is used; some installations exist where continuous and batch carburising are complementary to each other. Where varied treatments are required at unspecified times from the same furnace, or group of furnaces, it is an obvious advantage if the treatment given to each charge can be automatically controlled by some pre-set means, in order to maintain uniformity of the product, yet be sufficiently flexible to be easily adjustable from charge to charge. Considerable thought has been given to the development of a control system which will permit maximum flexibility, with fully automatic operation. The latest system of British Furnaces, Ltd., (Fig. 27), uses six adjustable time clocks: timing pre-soaking, carburising (or carbonitriding), diffusing, equalising, quenching, and

Courtesy of Incandescent Heat Co., Ltd.

Fig. 28.—One of a range of furnaces installed for continuous carburising and bulk quenching.

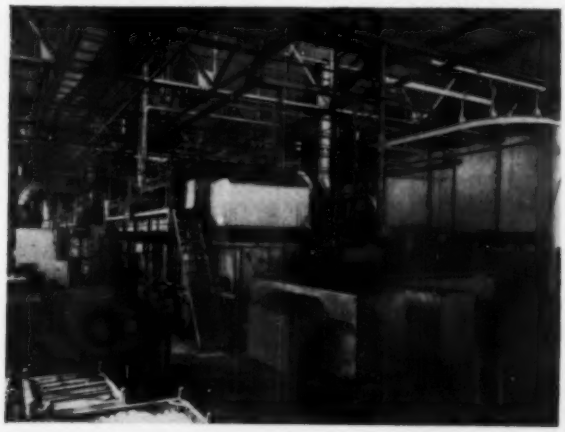
vestibule purging periods, together with a 2-point temperature recorder-controller, working in conjunction with the furnace mechanisms, through an electrical sequence control panel. A selector switch is provided to cover the three basic cycles, i.e., carburising, carbonitriding, and reheating. With this system it is possible to cover a wide range of case depths and case characteristics, merely by tuning clock adjustments. In most instances, with alloy carburising steels, it is desirable to quench from a reduced temperature after carburising, which involves cooling the charge to a uniform temperature of say, 840° C.

One of a range of furnaces being installed for the continuous carburising and bulk quenching of transmission components is shown in Fig. 28. This is a single track unit which can readily be incorporated in the smaller mass production shop. It offers, however, continuous and automatic treatment and is economical in capital and running costs: it is capable of outputs of 600 lb./hr. of carburised work. Heating is by means of fuel-fired radiant Jetubes, made in spun cast alloy and of very robust construction. This method of heating gives close uniformity of temperature, high rate of heat transfer to the stock, the minimum of maintenance trouble, and high overall thermal efficiency.

Two continuous gas carburising furnaces have been installed at the Radford Works of the Standard Motor Co., Ltd., by Gibbons Applied Atmospheres, Ltd. They

comprise identical single track pusher type furnaces, built by Thermic Equipment & Engineering Co., Ltd., and supplied with endothermic gas from a common range of generators. These furnaces (Fig. 29) are heated by Thermic radiant tubes, which are grouped in three controlled zones—heating, carburising, and diffusion—so that it is possible to heat up to carburising temperature as rapidly as possible and cool in the diffusion zone prior to quenching to minimise the retention of unchanged austenite. Three circulating fans are fitted, one in each zone, which have the double function of increasing the rate of heat transfer and ensuring the uniform distribution and flow of the carburising gases through the work stacked on the trays. All the moving parts on these furnaces are operated electro-mechanically through motors and reduction gears : they include the pushers, extractors, doors and lowerators, the only exception being the small door in the end wall through which press-quenched parts are withdrawn, which is operated by an electro-hydraulic thruster.

The generator installation, supplied by Gibbons Applied Atmospheres, Ltd., comprises three separate combustion chambers, each containing two catalyst tubes, so arranged that it is possible to use any two of these at one time, the remaining one acting as a spare. The flow of endothermic gas to each furnace is split into three main lines, one to the heating and carburising zones, one to the diffusion zone, and the third supplying the vestibules. Facilities are available for the propane enrichment of both the main supply lines to the furnace, but, in practice, it has only been found necessary to enrich that going to the first two zones. The endothermic generators, which automatically respond to variations in demand, are also used to supply batch type hardening furnaces.



Courtesy of Gibbons Applied Atmospheres, Ltd.

Fig. 29.—Two continuous gas carburising furnaces, built by Thermic Equipment and Engineering Co., Ltd., and installed at the Radford Works of Standard Motors Ltd.

For the continuous gas carburising of small parts either shaker hearth or rotary drum furnaces may be used. A recent installation of the rotary drum type is shown in Fig. 30 ; it comprises two furnace equipments which are being used at the Nottingham works of Raleigh Industries, Ltd., for the carbonitriding of cones and similar components, some trays of which are seen in the foreground. The necessary atmosphere being controlled from the panel on the left of the furnace in the foreground, while on the right is a pneumatically operated quench basket extractor.

Courtesy of Wild-Barfield Electric Furnace Co., Ltd.

Fig. 30.—Two rotary drum furnaces for carburising small components.

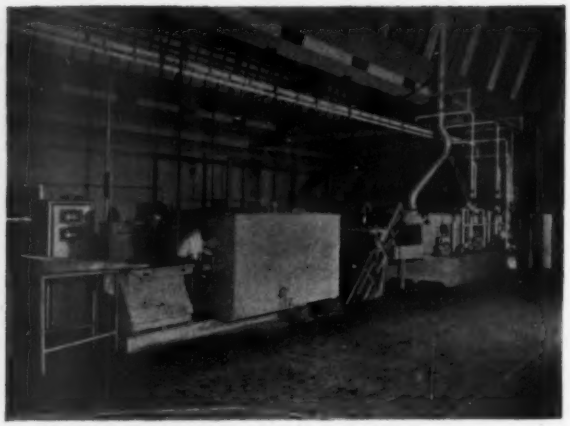
An Efco electrically heated gas carburising furnace has been installed in the works of Richard Sizer, Ltd., (Fig. 31), where it is used to carburise ring-type dies for use in machinery for extruding cattle feed. The largest dies measure 30 in. outside diameter, 22 in. inside diameter and 8 in. deep, weighing approximately 5 cwt. To avoid distortion, the dies are loaded into the furnace operating at 500° C. and are heated to 850° C. in 6 hours. After soaking they are quenched in oil and then tempered at 450° C. This furnace, which takes a charge of three large dies or six small ones, is rated at 100 kW. and has fully automatic temperature controlling and recording gear. The carburising atmosphere is produced from a liquid hydrocarbon introduced into the furnace by drip feed. It is admitted to the furnace when a temperature of 650° C. has been reached.

Courtesy of Efco Furnaces, Ltd.

Fig. 31.—Electric furnace for gas carburising dies for cattle food extrusion.

Courtesy of Wild-Barfield Electric Furnace Co., Ltd.

Fig. 32.—Part of a shaker hearth furnace installed for the heat treatment of bearing parts.



Courtesy of Efco Furnaces, Ltd.

Fig. 33.—Two shaker hearth furnaces, with closed-quench facilities, for hardening springs.

Electrically heated closed-quench furnaces have been installed during the period under consideration for gas carburising and carbonitriding small gears and pinions. One of these, made by Efco Furnaces, Ltd., provides a loading space 12 in. wide × 24 in. deep × 10 in. high. It is equipped with a purge chamber, a water-jacketed cooling chamber, an oil quench tank with oil cooler and agitator, air-operated double-level quench elevator, and an atmosphere circulating fan, controlled atmosphere being supplied from an Efco endothermic generator. A junior furnace to this design has been introduced as an economical unit for dealing with a smaller volume of work.

Hardening and Tempering

Several types of hardening and tempering furnaces have been commissioned during the period of this review. Of interest is one of the shaker hearth furnaces forming part of a Wild-Barfield installation at the Stonehouse Works of Hoffmann Gloucester, Ltd., shown in Fig. 32.

Courtesy of Efco Furnaces, Ltd.

Fig. 34.—Continuous driven roller hearth furnaces installed for hardening and tempering sprockets, hubs and shafts.

This furnace has two 12 in. hearth trays which run side by side through a chamber heated by tubular elements divided into two separately controlled zones. It will be noted that the equipment includes a continuous quench extractor for the automatic unloading of quenched work. Provision is made for a maximum operating temperature of 1,000° C. and the equipment is capable of handling 400 lb. of hardened components per hour, depending on the type of component treated. Protective atmosphere is provided by an endothermic generator and is introduced into the furnace by means of two branched pipes, one of each leads into each of the two quench chutes. At the entry end of this furnace is a water-cooled hood, which reduces the amount of radiated heat and improves working conditions for the operator.

Two shaker hearth furnaces providing closed-quench facilities (Fig. 33) have been installed by Efco Furnaces, Ltd., in the works of Herbert Terry & Sons, Ltd., at Redditch, for hardening springs. In both furnaces the springs are moved through a horizontal heating chamber by an oscillating nickel-chromium hearth plate having a machined and polished surface. The hearth is operated in one direction by an electric motor and in the other by a spring return mechanism and its oscillating frequency can be varied to give a wide range of conveyor speeds. The heated springs fall from the hearth through a quench chute which is sealed to the furnace casing and has its lower end projecting into the quenching medium.

One furnace is rated at 50 kW. and has a hearth 18 in. wide, with a heated length of 5 ft. controlled in two zones; its oil quench tank is fitted with an oil cooler and an oil circulating impeller. The other furnace is rated at 20 kW. and has a hearth 12 in. wide with a heated length of 2 ft. 6 in.; its quench tank is arranged with its effective length of 8 ft. at right angles to the line of the furnace. In both furnaces the springs are protected from oxidation and decarburisation by an endothermic atmosphere.

Continuous, driven roller hearth furnaces, such as Fig. 34, have been installed for the hardening and tempering of sprockets, hubs and shafts. The hardening furnace has a purging chamber, a preheating chamber and a heating chamber 24 ft. 6 in. long arranged in three independently controlled zones. It has a rating of 380 kW.,

provides for temperatures up to 1,000° C., and can be operated by hand or by automatic control mechanism using photo-electric devices.

The tempering furnace has a heating chamber 30 ft. long arranged in four separately controlled zones, and an unheated vestibule, 5 ft. long, at each end. This furnace is rated at 320 kW. and provides for a maximum temperature of 675° C. Forced air circulation is provided by powerful centrifugal type fans mounted in the roof of the heating chamber.

The sealed quench furnace shown in Fig. 35 is one of a range now being manufactured by the Incandescent Heat Co., Ltd. The smallest in the range has an effective work area of 3 ft. × 2 ft. × 1 ft. 9 in. and the largest 8 ft. × 3 ft × 2 ft., the latter believed to be the largest plant of its type in Europe. The furnace is suitable for controlled atmosphere heat treatment up to a temperature of 1,000° C., thus, in addition to clean hardening, it is equally suitable for carburising, carbonitriding, annealing and normalising. Varying degrees of automatically controlled mechanised operations are available, covering the process of charging the furnace, transferring of work trays, and quenching under controlled atmosphere conditions. The furnace is equipped with heat resisting alloy roller tracks, to facilitate charging and discharging of the charge, which is supported in jigs or baskets on alloy work trays. Heating of the furnace is by means of the patented fuel fired radiant Jetube system. This method of heating provides close uniformity of temperature, high rate of heat transfer to the stock, the minimum of maintenance trouble, and the maximum overall thermal efficiency.

The British Steel Chain Co., Ltd., have installed a hardening and normalising furnace of the Incandescent pit type (Fig. 36). It is arranged for town's gas firing, using specially designed radiant bowl burners for operating within the temperature range of 700°–950° C. The effective working dimensions of this furnace are 7 ft. deep × 5 ft. diameter for dealing with chains having a maximum length of 90 ft. of 2 in. thick material, and having an approximate weight of 25 cwt. The combustion system is divided into two zones, each zone being equipped with automatic temperature controlling and

Courtesy of Incandescent Heat Co., Ltd.

Fig. 35.—Sealed-quench furnace for Johnson, Matthey & Co., Ltd.

recording equipment. Tempering is carried out in a Metalectric electrically heated vertical air circulating furnace of similar dimensions. This furnace is designed for operating at temperatures up to 750° C., and the applied rating is 222 kW. The plant is complete with oil and water quench tanks, together with recirculation and cooling devices.

A vacuum purge controlled atmosphere furnace has been developed by Ipsen Industries, Inc., to complete their line of vacuum equipment which now covers treatment at temperatures ranging from 100°–2,200° C. in vacuum or atmosphere. This new unit allows bright tempering of work heat treated in the high temperature fast cooling vacuum furnace of the same dimensions without taking the work from the basket. It can also be applied for annealing or for the precipitation of many ferrous and non-ferrous materials.

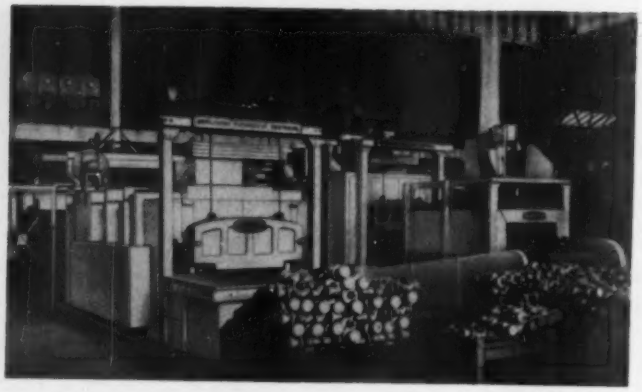
The furnace and vacuum unit shown in Fig. 37 occupy

Courtesy of Incandescent Heat Co., Ltd.

Fig. 36.—Installation for heat treatment of chains at the works of The British Steel Chain Co., Ltd.

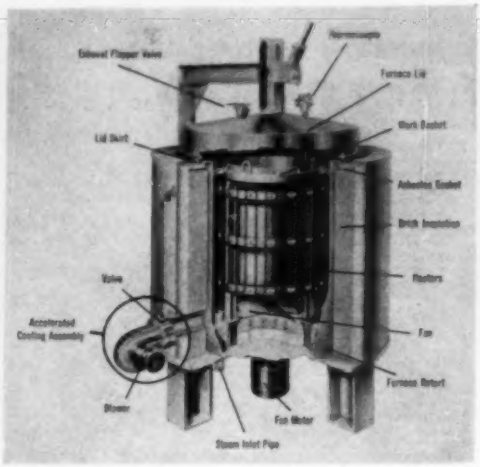
Courtesy of Ipsen Industries, Inc.

Fig. 37.—A vacuum purge controlled atmosphere furnace unit designed for temperatures up to 820° C.



Courtesy of Garringtons, Ltd.

Fig. 38.—Two cast link conveyor furnaces by Metalectric Furnaces, Ltd., for hardening and tempering forgings.



Courtesy of Leeds & Northrup, Ltd.

Fig. 39.—Exploded view of the new steam Homo tempering furnace.

only 48 in. × 42 in. floor space, with a nearby control panel 24 in. × 13 in. The work space is 10 in. diameter by 14 in. deep; heat input is 9 kW., with a maximum operating temperature of 820° C. The work basket is loaded vertically. In operation, the unit is vacuum purged and back-filled with inert, oxidising or reducing gas atmosphere at choice. The furnace may be operated under partial or full pressure with such gases as hydrogen, endothermic, cracked ammonia, etc. Powerful circulation of the atmosphere, over Inconel sheathed heating elements, provides full convection heating. Internal water cooling coils and directional baffles provide fast cooling.

Fig. 38 shows one of three continuous cast link conveyor hardening and tempering installations for heat treating, in the main, forged crankshafts, but also adapted for annealing miscellaneous forgings. This plant is designed for a continuous throughput of ¾ ton of forgings per hour, and an interesting feature is the heavy duty cast link conveyors embodied in the furnace, which permit the loading of large forgings, and their subsequent transfer to the quench tank, which incorporates a conveyor capable of accepting large forgings and taking them to a further intermediate conveyor to carry them to the charge end of the tempering furnace. To facilitate immediate handling from the tempering furnaces, cooling cowls are used through which the furnace conveyors are extended.

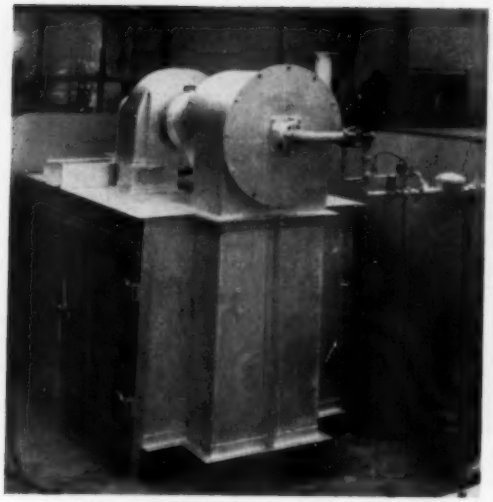
The total connected rating of the three installations is approximately 2,000 kW., and multi-zone control is used, together with air circulating fans in the tempering furnaces, to provide close temperature control. Further similar designs, with a total connected rating of approximately 4,000 kW. are at present being installed at the works of a prominent motor car manufacturing firm, and these embody automation in handling and continuous washing between the hardening and tempering furnaces.

Leeds & Northrup, Ltd., have recently introduced a new model of their steam Homo tempering furnace. This steam atmosphere treatment, during which a very thin film of oil-bearing zinc oxide is absorbed into the metal, is claimed to give greatly prolonged life to all cutting tools, gears and bearing surfaces. The new feature is a cooling blower assembly which accelerates furnace cooling on a production basis: this can be seen in Fig. 39.

The primary application of this new atmosphere tempering furnace is in stress relieving, age hardening or annealing parts made from non-ferrous metals, particularly copper or alloys with high copper content, in a steam atmosphere. Substantial saving in costs can be made by cooling parts in the furnace whilst under the protective steam atmosphere. Parts come from the furnace in a clean finished condition ready for plating or immediate use, thus eliminating the need for acid dips, pickling and rinses. Because this furnace is metal lined and effectively sealed, a suitable purified exothermic atmosphere or other inert gas can be used where ferrous parts require clean tempering. Furnace cooling rates are rapid and uniform; for example a 750 lb. net load can be cooled from 540° C. to 150° C. in 1½–2 hours. At the end of the heating cycle a butterfly valve is opened and a motor driven blower is turned on. Cool air is drawn in and circulates in the annular space between the brickwork and the outside of the alloy retort, effectively cooling the furnace load while the atmosphere on the inside of the retort protects the work.

A somewhat unusual low temperature furnace made by Dowson & Mason for Tempered Spring Co., Ltd., is shown in Fig. 40. It operates at 250° C. for the bluing of coil springs. To obtain a rapid rate of heat transfer, with accurate control, at this low temperature, heating is by a hot gas recirculating system consisting of a combustion chamber direct fired by one natural draught gas burner with pilot flame, connected to the inlet of a low pressure high capacity fan. Temperature control is by an expansion type instrument and solenoid valve. This furnace has a working space 5 ft. 6 in. wide × 2 ft. 10½ in. high × 4 ft. 4½ in. long.

Recent additions to the Barlow-Whitney range are their Series E 750/1100 FCH horizontal batch type electric furnaces for general heat treatment operations including, stress-relieving, tempering, precipitation treatment of non-ferrous metals, etc. These furnaces are provided with forced convection which is operative up to 750° C. If higher temperatures are required the air circulating fan is automatically shut down by the controller, permitting the temperature to be taken up to



Courtesy of Tempered Spring Co., Ltd., and Dowson & Mason, Ltd.

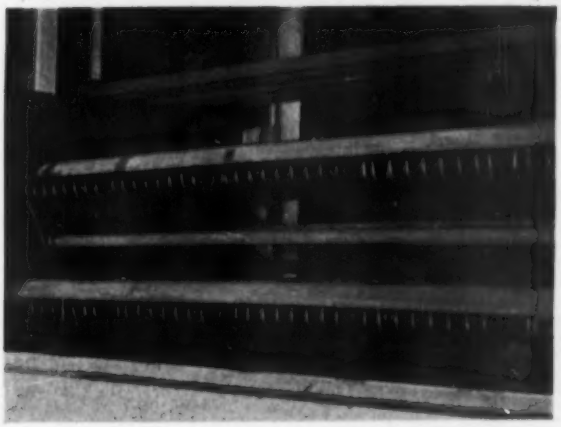
Fig. 40.—An unusual low temperature furnace designed for bluing coil springs.

1,100° C., the fan being protected from over-heating by a series of radiation baffles. This special and unusual feature greatly extends the useful operational function of these furnaces, and eliminates the complications associated with fans running at high temperatures. Sizes range from 12 in. × 6 in. to 36 in. × 24 in. × 96 in. long.

The rapid growth of clean hardening can be expected to lead to increased demand for clean tempering, and many Ipsen units for this purpose have already been sold in the U.S.A. Units can be supplied as box furnaces, but alternate designs permit atmosphere cooling, and/or oil quenching under atmosphere. Whether gas-fired or electric, heating is through ceramic radiant tubes in patented simple mountings. The work is completely shielded from direct heat by a muffle and uniformity is achieved by means of a powerful fan. Work transfer is by alloy conveyor chains which move the load into the atmosphere cooling chamber or onto the quench elevator.

Courtesy of Imperial Chemical Industries, Ltd.

Fig. 42.—A battery of "Cassel" C.A. automatic furnaces for casehardening cycle components.



Courtesy of J.L.S. Engineering, Ltd.

Fig. 41.—Close-up of the conveyor in gas-fired air-circulating spring tempering furnaces.

A ducted fan and water jacket gives rapid atmosphere cooling where this is employed. When oil quenching, an insulated tank, controlled two-speed circulation and oil temperature control through built-in heaters and coolers is standard.

Modern specifications for production springs call for increasingly more accurate heat treatment conditions, and the use of air circulating furnaces, where uniformity throughout the charge can be achieved, is coming more and more to the fore. J.L.S. Engineering Co., Ltd., have recently installed at Toledo Woodhead Springs Ltd., a conveyorised gas fired spring tempering furnace incorporating a vertical conveyor. The method of loading the conveyor is shown in Fig. 41, from which it will be seen that the unit is handling road vehicle coil springs contained in conveyor troughs. The output is up to 2 tons per hour, with a treatment time of 40 minutes or more, depending upon the gauge of wire. A remote control position provides for conveyor speed adjustment. The furnace walls are of 10 s.w.g. steel inner and outer cases with 8 in. of best quality low thermal capacity insulation between. Air re-circulation in the order of 24,000 cu. ft./min. ensures uniformity of heating and the temperature is controlled by two indicating controllers.

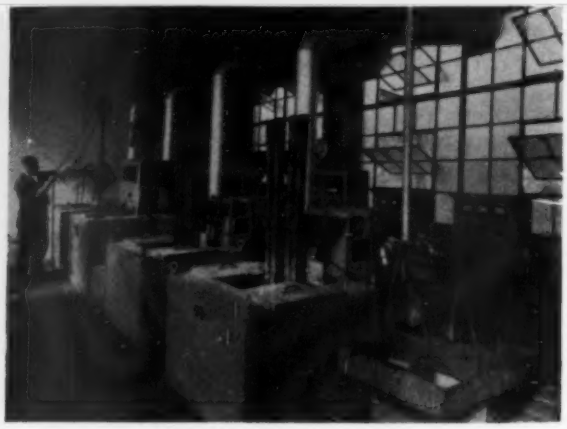
Salt Bath Furnaces

Salt bath furnaces are finding increasing application for a range of heat treatments. They find favour for carburising because the results are readily reproducible and quality control is easy. Fig. 42 shows a battery of 'Cassel' C.A. automatic furnaces now in use with cyanide/carbonate baths for casehardening cycle components.

Because of the good finish, low distortion and ease of handling, the trend to salt baths for the treatment of hot work steels with an isothermal quench continues; a recent installation of 'Cassel' furnaces is operating on dies and tools in 5% chromium-molybdenum steel, covering preheat, high heat, salt quench and temper. A new departure is the application of the austempering process to the treatment of paint scraper blades and trowels. These are austenitised and austempered in the

Courtesy of Imperial Chemical Industries, Ltd.

Fig. 43.—"Cassel" Ajax electrically heated plant for the application of the austempering process to the treatment of paint scraper blades and trowels.

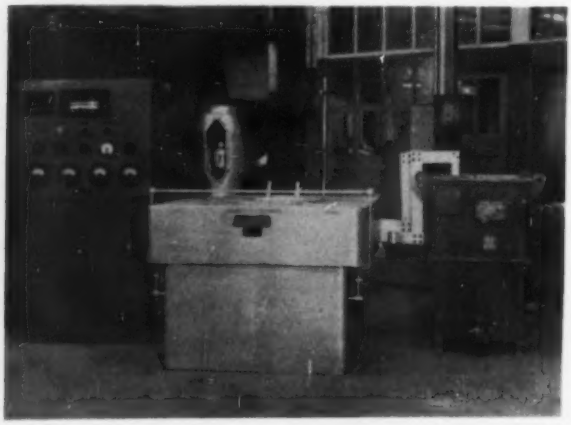


Courtesy of Efco Furnaces, Ltd.

Fig. 44.—Salt bath furnaces installed at the works of Henry Rossell & Co., Ltd., for the treatment of high speed steel tools.

'Cassel' Ajax electrically heated plant shown in Fig. 43, and finally temper flattened in clamps in an air circulating furnace.

A battery of salt bath furnaces has been installed at the Sheffield works of Henry Rossell & Co., Ltd., for the treatment of high-speed steel tools. The tools are preheated in a refractory lined, knee-type-electrode salt bath rated at 40 kW. and operating within the range 830°–840° C. The tools are heated to 1,280°–1,290° C. for hardening in another refractory lined, knee-type-electrode salt bath, also rated at 40 kW. The quench salt bath is of the suspended electrode type, rated at 35 kW., the quench salt being heated to 550° C. An identical bath of the suspended electrode type is used for secondary hardening at a temperature of 550° C. In this installation, shown in Fig. 44, the tools and their carriers are heated in an oven prior to being immersed in the preheat bath, to avoid splattering, and they are cleaned after processing in hot and cold water washing tanks.



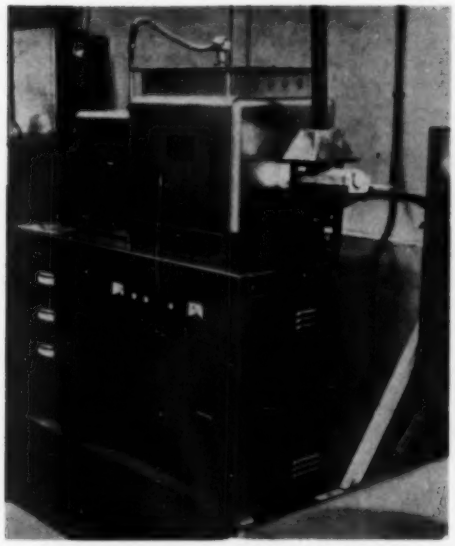
Courtesy of Brayshaw Furnaces, Ltd.

Fig. 45.—A new design of electrode salt bath furnace recently installed.

A new installation is the Brayshaw electrode salt bath furnace shown in Fig. 45. In this design the electrodes are located in recesses equally spaced around the circumference and immersed in the salt; they are connected to each phase. The salt is heated by a low voltage alternating current passing between the immersed electrodes. Two auxiliary electrodes (removable) are provided to facilitate starting up, powered from two of the phases. These auxiliary electrodes are brought into circuit by locating them in specially designed brackets on the main busbars and are withdrawn during normal operation. An exhaust duct with powerful suction fan dispels fumes arising from the top of the salt, maintaining a clear field of vision over the salt level.

General and Special Duty Furnaces

The semi-conductor industry has created a new field for small, accurately controlled furnaces to work at laboratory standards of cleanliness. Furnaces are required for the reduction of germanium oxide, for solid and vapour diffusion, for alloying, for brazing, and for glass-to-metal sealing. During the past few years Royce Electric Furnaces, Ltd., have given special attention to designing and manufacturing furnaces for use in both the development and the production of semiconductors. New high temperature diffusion furnaces, for instance, have been installed in the Transister Division of Standard Telephones and Cables, Ltd. The furnaces are self-contained units (Fig. 46) incorporating a floor-standing cabinet housing all the electrical gear. They are suitable for use with nitrogen, oxygen and hydrogen atmospheres and are designed to take work tubes of either impervious fused alumina or transparent silica having an inner diameter of 2 in. Each furnace has a preheat section with a heated length of 12 in. arranged in three zones and providing temperatures from 200°–1,000° C., and a high temperature section with a heated length of 15 in. providing temperatures between 950° and 1,300° C. The temperatures of the two sections are independently controlled and, within the specified temperatures ranges, any desired temperature can be maintained in either section irrespective of the operating temperature of the



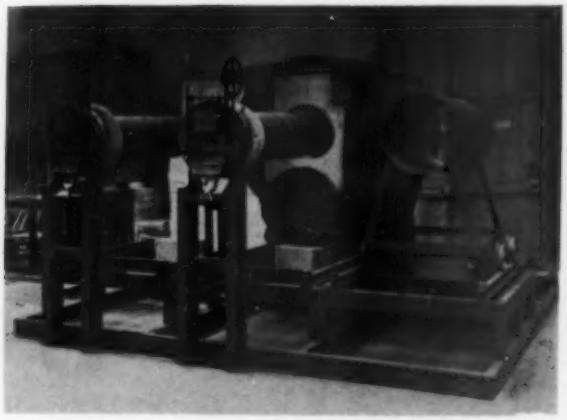
Courtesy of Royce Electric Furnaces, Ltd.

Fig. 46.—New high temperature diffusion furnace used in the production of semiconductors.

other section. The furnaces are so designed that a fall in temperature cannot occur between the zones. Each furnace is rated at 7½ kW.

A continuous mesh belt conveyor furnace for alloying germanium, supplied by Royce to Newmarket Transistors, Ltd., is arranged in twelve separately controlled zones. It has a total length of 22 ft. 6 in., with a heated length of 10 ft. The conveyor belt is 1½ in. wide and travels at speeds up to 12 in./min. This furnace is rated at 24 kW. and provides temperature up to 1,000° C.

Amongst several other designs is a furnace supplied to a valve manufacturer for brazing valve assemblies in vacuum. The cylindrical chamber is water cooled and fitted with a domed lid. The heating element is a molybdenum cylinder surrounded by radiation screens, and providing usable dimensions 8 in. diameter × 8 in. high. It is rated at 20 kW. and provides temperatures up to 1,200° C. A new type traversing furnace has been designed for brazing valve assemblies in a hydrogen atmosphere. In this case the work is loaded into horizontal cylindrical retorts which are gas-tight sealed with a front door having a quick release clamp. As shown in Fig. 47 two retorts are used. They are fitted to a fixed stand and the furnace is traversed between the two positions where it can be moved forward to heat each retort in turn. The retorts have an inner diameter of



Courtesy of Royce Electric Furnaces, Ltd.

Fig. 47.—New type traversing furnace designed for brazing valve assemblies.

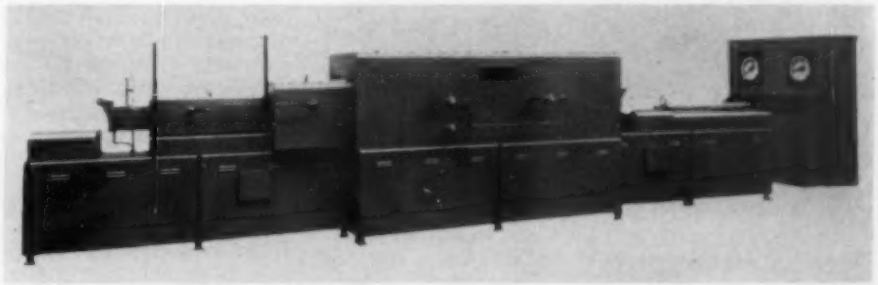
12 in. and a uniformly heated length of 21 in. The rating is 40 kW., so that the retorts can readily be brought to the maximum operating temperature of 1,200° C.

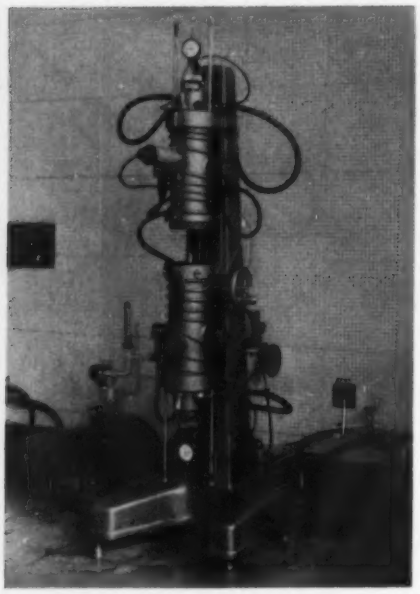
A new type of open hearth pusher type furnace, rated at 18 kW., has been designed by Sintering & Brazing Furnaces, Ltd., for use with either inert or reducing atmosphere at temperatures up to 1,500° C. It has two heating zones, each 3 ft. 6 in. long and effective area of 6½ in. wide × 8 in. high. The furnace is shown in Fig. 48, complete with pneumatic pusher gear. Molybdenum elements of the open radiation type are used, being situated at both sides and below the work area. Automatic temperature control is of the conventional type to give a high degree of accuracy. Furnaces of similar design are manufactured with zone cross-sections of up to 15 in. wide × 12 in. high for temperatures up to 1,750° C. in reducing atmospheres, 1,650° C. in oxidising atmospheres, or 1,500° C. in inert atmospheres.

Since mid-1960 Vacuum Research (Cambridge), Ltd., have continued to design, develop and make non-standard furnaces and associated equipment. These furnaces have used high vacuum either for vacuum purging and subsequent back-filling with inert gas or as the actual process environment. Among these is a high vacuum brazing furnace for the Admiralty, capable of batch processing charges weighing 20 lb. at 1,300° C. at 10^{-4} mm.Hg. The work chamber is horizontal, stainless steel and water jacketed, and pumping is provided by a 9 in. diffusion pump combination associated with a liquid-gas cooled trap. The process operations are arranged for push-button control.

Courtesy of Sintering & Brazing Furnaces, Ltd.

Fig. 48.—This open hearth pusher type furnace is designed for use with inert or reducing atmospheres at temperatures up to 1,500° C.





Courtesy of Vacuum Research (Cambridge), Ltd.

Fig. 49.—The Type YM-4R vacuum furnace is used here for Young's modulus determinations at temperatures up to 1,000° C.

Another interesting feature is a high vacuum furnace arranged for the ultrasonic determination of Young's modulus of elasticity, for specimens in rod or sheet form, at all temperatures between 1,000° C. and —160° C. This furnace is also under development for many other processes and treatments involving temperature, high vacuum or inert atmosphere. Fig. 49 shows a rig arranged for the longitudinal excitation of a rod specimen at resonant frequency under electronic control and analysis for the determination of the Young's modulus of elasticity and the damping constant.

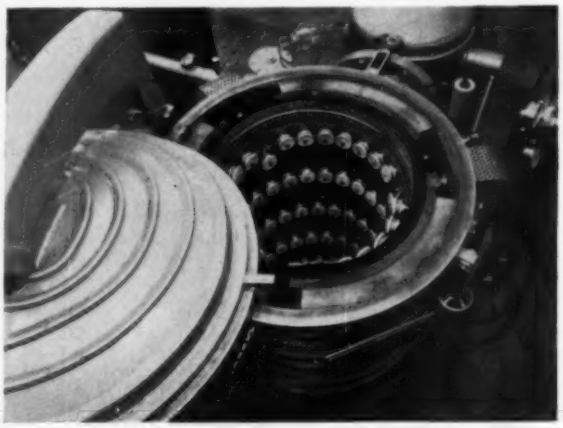
A tantalum sintering furnace has recently been developed by Vacuum Metallurgical Developments, Ltd.; it is resistance heated and provision is made for an ultimate vacuum better than 10^{-5} mm. Hg. The furnace has a water-cooled stainless chamber which houses a tantalum element through which the heating current is passed. A fast pumping system is included of sufficient capacity to cope with the high outgassing of the compacted powder. Manually or electro-pneumatically operated valves are included to control the system. The heating chamber has an inside diameter of 14¼ in. and is 28 in. long. The heating element is constructed of tantalum sheet in three segments riveted to three connectors of sheet tantalum; these connectors, which are held in water-cooled copper electrodes, also support the elements.

Courtesy of Vacuum Metallurgical Developments, Ltd.

Fig. 50.—A tantalum sintering furnace using a tantalum heating element.

To operate the furnace the charge is loaded on a five-tier tray assembly and lowered into the chamber. After replacing the charging cover, the vacuum pumping system is then brought into action and finally the resistance heater is switched on. After heating is completed, rapid cooling is effected by admitting argon and switching on a re-circulating fan. This equipment, shown in Fig. 50, is designed for temperatures up to 2,000° C.

There are many advantages to be derived from brazing *in vacuo*, and Fig. 51 illustrates a Wild-Barfield internal element vacuum furnace employed for brazing special assemblies at the Services Electronics Research Laboratories (Microwave Electronics Division) Harlow. The



Courtesy of Wild-Barfield Electric Furnaces, Ltd.

Fig. 51.—Internal element vacuum brazing furnace.

maximum operating temperature of 1,200° C. is provided by a braided molybdenum heating element supported in a sinuous loop arrangement and surrounding the charge zone, the useful hot zone dimensions being 15 in. diameter and 24 in. deep. In the base of the furnace a molybdenum hearth plate supports up to 100 lb. of distributed load. Thermal insulation consists of a number of light gauge molybdenum and stainless steel radiation shields supported within a heavy gauge stainless steel canister. The stainless steel tank is water cooled by means of copper coils attached to the exterior surfaces. Control of power input is effected by means of three saturable reactors connected in series with the transformer windings, and power requirements vary up to a maximum input of 60 kW. A 50 c.f.m. rotary air

ballast pump is used to evacuate the furnace tank to about 0·1 mm. Hg. and a 1,200 c.f.m. oil diffusion pump reduces the pressure to approximately 0·01 micron.

A G.E.C. furnace rated at 150 kW. and in the process of being commissioned is designed for heat treatment and brazing under vacuum of Nimonic 75 and stainless steel components. The charge space is cylindrical in shape, 24 in. in diameter and 36 in. high, and is suitable for operation at temperatures up to 1,300° C. and pressures down to 10^{-4} mm. Hg. A novel feature of the installation is the ability to quench in water directly from the heating chamber. The company has recently received an export order for a 300 kW. vacuum brazing installation to be used for the heat treatment and brazing of Nimonic 75 and Nimonic 90 components.

Courtesy of Barlow-Whitney, Ltd.

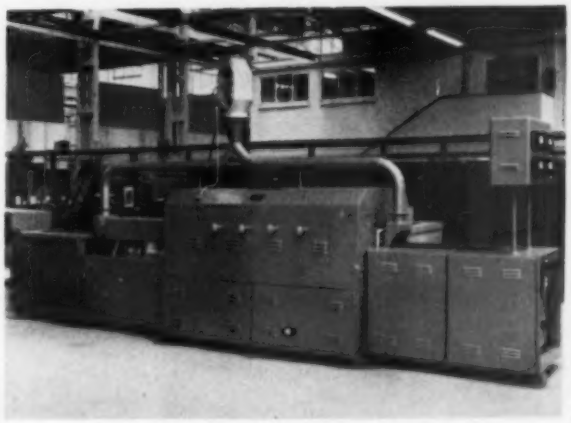
Fig. 52.—Electric bell furnaces for brazing, bright annealing, etc.

A new range of standard electric bell-type furnaces has been introduced by Barlow-Whitney, Ltd., for bright annealing, brazing, sintering and other heat treatment operations necessitating low dewpoint reducing atmospheres, usually hydrogen or hydrogen nitrogen mixtures. Standard muffle sizes range from 12 in. diameter upwards, with heights to suit requirements. A typical installation is shown in Fig. 52.

A new Royce mesh belt conveyor furnace (Fig. 53) is a self-contained unit with automatic temperature controllers for the three-zone heating chamber mounted above the loading position together with an excess temperature controller, and all electrical control gear housed inside the furnace casing. The overall length of 20 ft. is made up of loading, preheating, heating, cooling and unloading sections. The work is heated and cooled in a gas tight muffle having fume extraction gear at both ends. The furnace is rated at 21 kW. and provides temperatures up to 700° C.

Induction Heating

Quite a wide range of power units and specialised work handling machines have been developed during the last decade or so, with the result that some form of induction heating is now to be found in every large engineering factory. This method of heating frequently offers practical and economic advantages for some heat treatment processes. It is noteworthy, therefore, that Delapena & Son, Ltd., have extended their range of

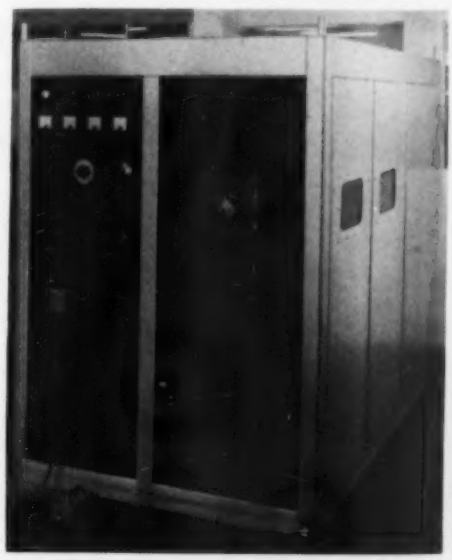


Courtesy of Royce Electric Furnaces, Ltd.

Fig. 53.—Mesh-belt conveyor furnace.

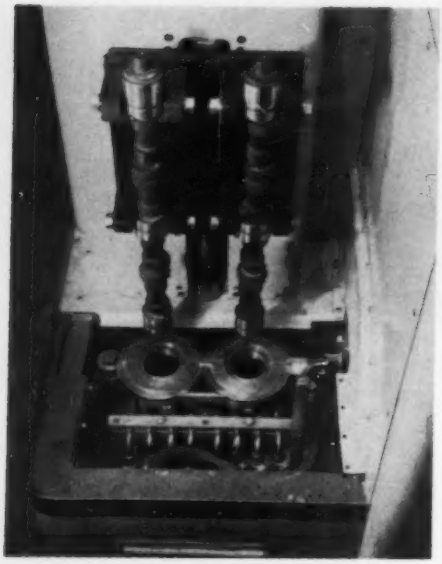
radio-frequency induction heaters by introducing three new high-efficiency models, suitable for a wide variety of work including hardening of large shafts and cylinder bore hardening, of greater power output than any previous equipment in the range. The new models, two of which have output ratings of 75 and 100 kW., respectively, and the remaining one a continuous output of 75 kW. all have a nominal output frequency of 150 kc/s.

High efficiency, when operating with a wide range of inductors and workpieces, can be maintained: (1) by the use of alternative high and low impedance output terminals in conjunction with the use, when necessary, of a specially designed external high-efficiency R.F. transformer; (2) by means of an external voltage regulating transformer which enables the output power to be varied



Courtesy of Delapena & Son, Ltd.

Fig. 54.—One of a range of radio-frequency induction heaters for surface hardening shafts and cylinder bores.



Courtesy of Birlec Efco (Melting), Ltd.

Fig. 55.—The gear and fuel pump eccentric station of an installation for induction hardening camshafts.

over a range of 16 : 1 ; (3) by the provision of variable kVA. boost, adjustable both by removable links and push-button operated contactors. The first of the series, a 75 kW. unit, embodying all three optional systems, was recently delivered to a customer in Switzerland ; it is similar to that shown in Fig. 54.

A recent installation comprises three main items, namely a Wild-Barfield 25 kW. induction heating generator incorporating automatic two-station switching and two separate handling fixtures, one for hardening and the other for tempering and shrinking. This equipment is used for hardening, tempering and shrinking ring gear components in an Australian motor car factory. The problem presented was that of hardening and tempering the teeth of starter rings and subsequently shrinking the rings on to flywheels.

The latest induction generator marketed by the Process Heating Division of Pye, Ltd., is a 12 kW. unit, is available in either air or water cooled versions, and has been designed for continuous operation. The availability of medium and high work coil kVA. permits the heating of a wide range of ferrous and non-ferrous loads. The output power can be varied by means of a stepped control. Accurate repetition work can be carried due to the inclusion of an automatic resetting process timer. The safety devices include water pressure switches, overload relays and safety switches behind movable panels. Provision is made for remote output power indication and on/off control ; also coloured indicator lamps show which circuits are switched on. Due to the simplicity of operation, unskilled labour may be employed enabling production costs to be reduced.

In induction hardening axle shafts, the shaft may be passed through an inductor and quench being rotated at the same time ; alternatively, the shaft may be rotated (but otherwise stationary) whilst the inductor and quench is progressed along it. In a recent installation of the first type, made by Birlec-Efco (Melting), Ltd., $1\frac{1}{8}$ in. diameter shafts are treated two at a time, with an output of the order of 30-60 shafts per hour, depending on the length : the H.F. power is supplied by a 200 kW., 2·25 kc./s. motor generator. The second type of installation is usually used for long and large diameter shafts, requiring as it does less headroom for the same length of shaft. Birlefco equipment is under construction for treating two shafts at a time with a special loading arrangement. The rating is 300 kW. at 3 kc./s. and it is expected that output will be of the order of 20–25 per hour of shafts approximately $1\frac{3}{4}$ in. diameter. Both types of machine are able to deal with hardening into the radius of the axle shaft flanges, if required, and the speed and/or power can be varied automatically during the cycle, according to a predetermined schedule.

Electro-Heat Congress Proceedings

THE proceedings of the Fourth International Congress on Electro-Heat, held in Stresa, Italy, in May 1959, have now been published in two volumes. The first of these contains the programme and a general report of the congress, all the discussions, and a complete index, whilst the second volume includes all the 185 papers presented at the congress, each being printed in that one of the three official languages—English, French, and German—in which it was presented. A summary of the contents of each paper is provided in each of these three languages.

The two volumes contain a wealth of information on electro-heat applications and developments up to 1959, and much of this is of interest in the metallurgical field. Copies may be obtained at a cost of 35,000 Italian lire from the publishers, Comitato Elettrotecnico Italiano, Via San Paolo 10, Milano, Italy. Further information can be obtained from the Secretary, the British National Committee on Electro-Heat, c/o The British Electrical Development Association, 2 Savoy Hill, London, W.C.2.

United Steel Airstrip

THE UNITED STEEL COS., LTD., have purchased 108 acres of land near Coal Aston, ten miles to the south of Sheffield, for development as an airstrip for use by the company's aircraft. Town planning approval has been given to this project and work is now proceeding on the preparation of an 800-yard long grass runway. When completed in the early summer, it will enable customers and senior executives to reach United Steel's head office in fifteen minutes by car, with about half-an-hour's travelling to the company's steelmaking branches in the Sheffield area. At present United Steel's two aircraft—a four-seater Piper Apache and a Piaggio P166—are based at Ringway Airport, Manchester.

Cybernetics Congress Proceedings

THE INTERNATIONAL ASSOCIATION FOR CYBERNETICS has now issued the Proceedings of the Second International Congress on Cybernetics, held at Namur, Belgium, in September 1958. This important 1,000 page illustrated scientific publication, which includes eighty of the papers read at the congress by scientists of all disciplines and nationalities, is available from the Secretariat of the Association Internationale de Cybernétique, A.S.B.L., 13 rue Basse-Marcelle, Namur, Belgium. The price is 800 Belgian francs for members of the Association, and 1,200 Belgian francs for non-members.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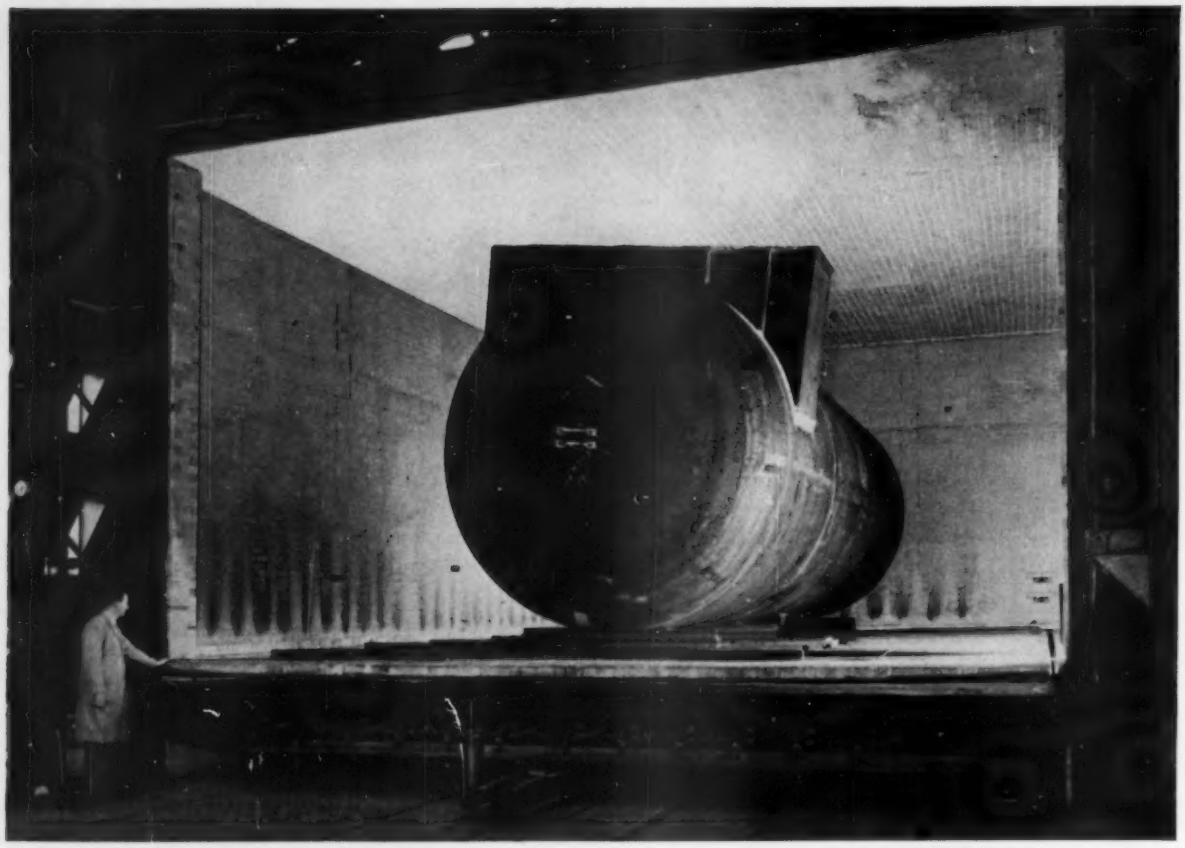

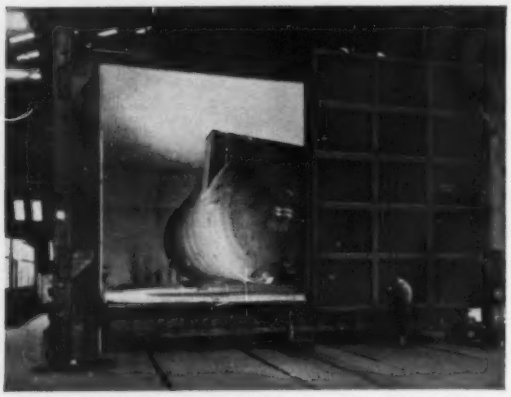

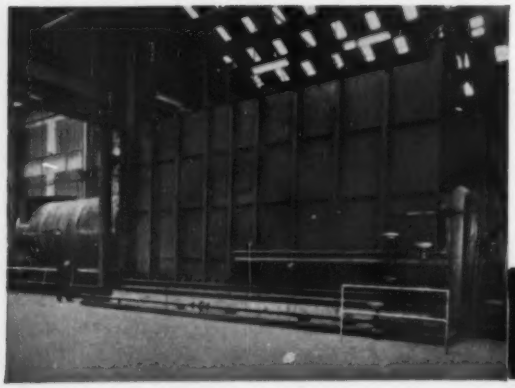

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The large stress relieving furnace installed at the Dalmuir Works of Babcock & Wilcox Ltd. has a door opening 26′ 0″ wide x 15′ 3″ high from the flat top of the bogie to the underside of the furnace roof with an internal length of 32′ 0″.
It is designed for stress relieving operations in the temperature range of 600 - 650°C. and is also capable of operating at temperatures up to 900°C. with a maximum load on the bogie of 100 tons.

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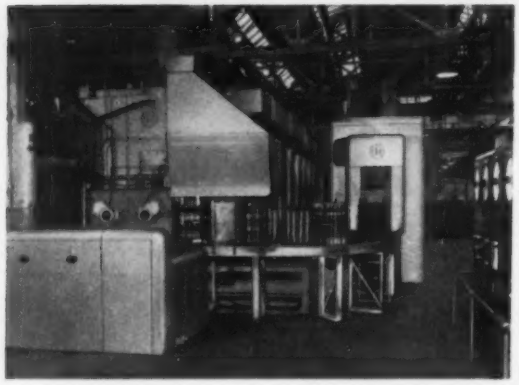

Illustration above : Loading and control bay for two Towns Gas Fired Pusher Continuous Gas Carburising Furnaces, 30 tray, two track for Crown Wheels, individually quenched.

Left hand illustration : Loading, Unloading and Control Bay for one Fully Automatic Towns Gas Fired Pusher Continuous Gas Carburising Furnace, 30 tray, two track, for Gearbox components, Cluster Gears, Pinions and Shafts, with integrated bulk quench, two stage wash and electric tempering.

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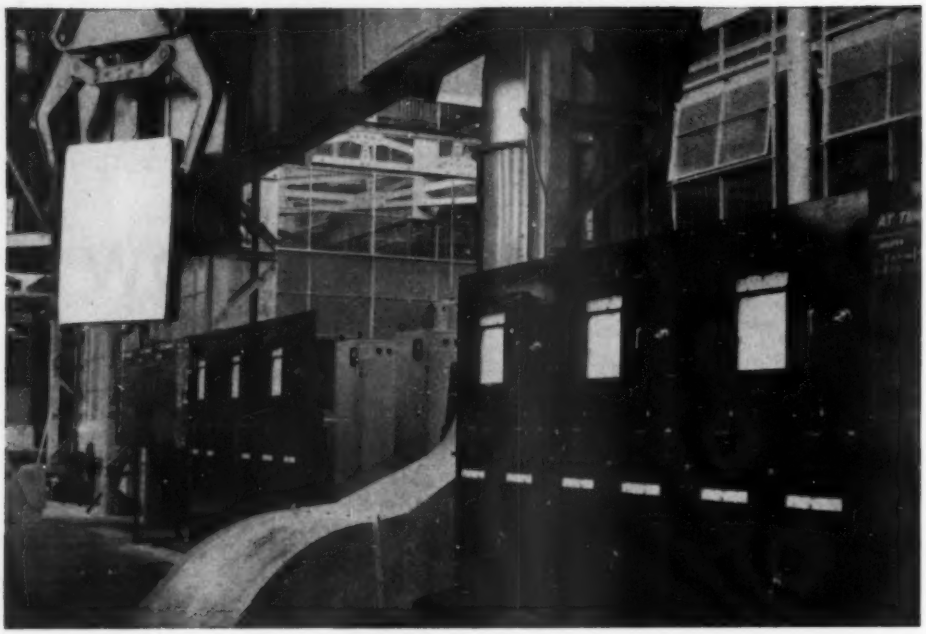

LEEDS NORTHRUP

Billet Production Control at Northern Aluminium Co. Ltd.

WE are indebted to the Northern Aluminium Co. Ltd. (Alcan G.B. Ltd.) for the above picture of part of the Leeds Northrup instrumentation controlling billet production at their Banbury works.

Furnace temperature/time is rigidly controlled and continuously recorded on the charts.

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NEWS AND ANNOUNCEMENTS

Conference on Anodised Aluminium

THE ALUMINIUM DEVELOPMENT ASSOCIATION, with the University of Nottingham Department of Metallurgy, is organising a residential conference at the University from 12th to 14th September, 1961. There will technical sessions on the afternoon of Tuesday, 12th September, and morning and afternoon sessions on Wednesday. The conference will end officially after breakfast on Thursday.

The aim of this conference is twofold :—

To provide an opportunity for anodisers, users of anodised aluminium, and the industry generally to discuss the latest technical developments.

To give research workers in this field an opportunity to discuss the fundamental aspects of their subject.

Fifteen papers, by British and foreign authors, will be presented. They will be grouped into six sessions under separate headings, and to make the best use of time available will be printed and distributed well before the conference; in this way the appropriate papers can be briefly introduced at each session and the rest of the time devoted to discussion and authors' replies. Sessions III and IV, which will appeal to different groups of people, will be held at the same time ; Sessions V and VI will be arranged in a similar manner.

Accommodation will be in Cripps Hall, a new university building, and the all-in charge for the conference is 5 guineas ; for two nights only—4 guineas ; and for meals only—3 guineas for each person. There is limited accommodation for members of the conference who wish to bring their wives.

Further details can be obtained from The Secretary, The Aluminium Development Association, 33 Grosvenor Street, London, W.1. Early application is desirable as there may have to be some limitation on numbers.

The Institution of Metallurgists

AT the seventeenth annual general meeting of the Institution of Metallurgists, held at the Park Lane Hotel, London, on Wednesday 17th May, DR. N. P. ALLEN, F.R.S., Superintendent of the metallurgy division at the National Physical Laboratory, took over the presidency from MR. W. E. BARDGETT. Other members elected to office in the Institution were : *senior vice-president*—DR. E. G. WEST ; *vice-presidents*—MR. F. DICKINSON and DR. L. NORTHCOTT ; *hon. treasurer*—MR. L. W. DERRY ; *members of council*—MR. H. MORROGH, MR. S. S. SMITH and DR. J. C. WRIGHT.

Non-Destructive Testing Conference

A CONFERENCE organised by The Non-Destructive Testing Society of Great Britain will be held in Chester from 21st to 23rd September, 1961, and will have as its theme " Industrial Radiology Today." The papers will include such subjects as low kV. radiography, Xero-radiography, linear accelerators, betatrons, large gamma ray sources for radiography, and current safety regulations. A works visit will be included in the programme, and a dinner for those participating is to be arranged for the evening of 22nd September.

The conference is open to all who are interested, whether members of the Society or not. A conference fee will be charged, which will include the cost of morning and afternoon refreshments ; this will be 15s. for members and 30s. for non-members. Further details may be obtained from Mr. I. M. Barnes, Non-Destructive Testing Conference Secretary, de Havilland Aircraft Co., Ltd., Manor Road, Hatfield, Herts.

Wellman-Incandescent Heat Merger

THE merger of The Incandescent Heat Co., Ltd., and its subsidiaries with the Wellman group has now taken effect, and although it is the intention that the Incandescent group shall continue to operate as an autonomous unit, the future close co-operation between these two groups should be mutually beneficial, as their products are mainly complementary.

Both Wellman and Incandescent construct furnaces for the metallurgical industries, but whereas Wellman specialise more on the larger melting furnaces and oxygen steelmaking processes, including the heavy duty mechanical equipment, the Incandescent group's activities are, in the main, concentrated on the finishing processes of steel and non-ferrous products, such as annealing and heat treatment furnaces embodying a wide range of thermal engineering throughout the metallurgical, chemical, foundry, ceramic, and other industries. Incandescent specialities also include electric furnaces for melting and heat treatment processes.

In their field, Wellman are specialists in the design and manufacture of furnace charging and discharging machines and thus the combined spheres of operation of the two companies will be enlarged. In the export field for integrated steel plants, the two companies with their joint resources will be in a position to undertake the whole of the furnace work from steel melting, including electric furnaces, down to the smallest finishing and heat treatment units.

A New Continuous Casting Process

CONTINUOUS casting is one of the recent developments in the steel industry now beginning to play an important part in the realisation of the industry's planned expansion. By enabling billet and bloom sections to be produced direct from molten steel, continuous casting eliminates some of the costly primary rolling processes. It has become evident that, since very high speed continuous casting leads to defects in the steel, and requires inconveniently high casting machines, it is necessary to use complex multi-strand casting machines for bulk steel manufacture.

A far more convenient method, as an alternative to these multi-strand plants, has recently been evolved by the Continuous Casting Company Ltd., Weybridge, in conjunction with the British Iron & Steel Research Association. This consists of an entirely new process—called the Weybridge process—which enables the casting speed to be kept to the optimum and permits the production of billet or bloom sections at rates comparable with

those obtained with multi-strand plants, but without the additional operating expense normally associated with them. The process is based on the use of a multiple mould having a cross-section such that the resulting casting comprises several billet or bloom sections interconnected at their corners, which are subsequently separated to form a number of individual castings.

World's Widest Aluminium Mill

THE BRITISH ALUMINIUM CO., LTD., are to spend over £10 million on new equipment as an extension to their Falkirk rolling mills in Scotland. The first stage comprises a hot mill approximately 172 in. wide which will treble Falkirk's ultimate capacity to 150,000 tons a year. Work will begin immediately and cold rolling and finishing capacity will be increased to absorb the hot rolling capacity over a succeeding period as the growing market for aluminium warrants. This will be the widest aluminium rolling mill in the world.

The company anticipates that aluminium usage will grow by at least the national average rate of industrial growth, and for markets such as packaging, transport, building and household appliances the rate should be even higher. This additional facility will enable B.A. to remain fully competitive in world markets.

Induction Heating Courses

THE next induction heating course in the series organised by Pye, Ltd., will be held at the Globe Hotel, Hills Road, Cambridge, commencing at 2 p.m. on Tuesday, 3rd October and finishing at 5–30 p.m. on Wednesday, 4th October. It will be run on similar lines to previous courses, namely, covering the fundamentals of induction heating, annealing and tempering of small parts, brazing, soldering and processing of conducting materials. There are no fees, and further information may be obtained from Mrs. E. Raeburn, Pye Process Heating, 28 James Street, Cambridge.

Blast Furnace Agreement

NEWTON CHAMBERS & CO., LTD., Thorncliffe, Sheffield, have entered into an exclusive agreement with John Mohr & Sons, of Chicago, for the sale, manufacture and installation in the United Kingdom and parts of the Commonwealth of blast furnaces complete with all ancillary equipment to the latest designs of the Mohr Company. John Mohr & Sons have been working in this field since 1857 and are one of the leading designers and constructors of blast furnaces and steelworks equipment in America. Newton Chambers, whose ironworks were established in 1793, operated their own blast furnaces until comparatively recently, and have themselves constructed blast furnaces and all types of ancillary equipment for steelworks. This agreement will enable Newton Chambers to keep abreast with the requirements of the iron and steel industry arising from the new manufacturing methods now being adopted throughout the world.

John Mohr & Sons have played a leading part in advances in blast furnace design, and installed the first blast furnace in the world to work at high top pressure—for the Republic Steel Corporation of America, at their Cleveland Works in 1942. Since then they have installed or have under construction, some twenty blast furnaces for American steelworks. Their success in this field was further recognised a few months ago when the United States Steel Corporation placed an order with them for the installation at the Duquesne Works, Pennsylvania, of a furnace having a hearth diameter of 28 ft. working at 30 lb./sq. in. top pressure, fully equipped, even to the extent of a completely automatic stock-house, and having a capacity of up to 4,000 tons of pig iron per day. This furnace will incorporate a Mohr patented three-bell charging system.

Apart from the furnaces themselves, Newton Chambers will have available the American company's latest designs for gas cleaning plant, hot blast stoves, valves and their automatic control, programme control up to the highest level of the completely automatic stock-house, and an established improved system of control for high top pressure—together with all ancillary equipment such as hot metal torpedo-type mixer cars, hot metal mixers, carriages, etc.

Ipsen Industries, Ltd.

IPSEN INDUSTRIES INC., of Rockford, Illinois, in association with Ipsen Industries International G.m.b.H., of Kleve, West Germany, manufacturers of atmosphere and vacuum automatic heat treatment equipment and associated plant, have formed a British company, Ipsen Industries, Ltd., with an address at 53 Victoria Road, Surbiton, Surrey, to facilitate further expansion of sales and service in Great Britain. Mr. L. E. Plimley has joined the British staff and operates from 38, Monckton Road, Quinton, Birmingham, 32 (Woodgate 4041). Several Ipsen installations are already in operation in this country and many more are in hand for the future.

Gear Heat Treatment Plant

BRITISH FURNACES, LTD., Derby Road, Chesterfield, have recently received orders for gas carburising equipment for the Scotstoun factory of Messrs. Albion Motors, Ltd. They will supply four Super Allcase sealed quench furnaces, complete with fully automatic sequence control, together with the necessary dew point controlled RX endothermic atmosphere generating plant, and other ancillary equipment, such as tempering furnace, power operated charging machine, etc. This plant will provide completely up-to-date final heat treatment for Albion's transmission gears.

British Instron, Ltd.

INSTRON, LTD., announce that Instron precision testing equipment is now made at a new factory at High Wycombe, Bucks. Instron equipment was first developed by Messrs. Hindman and Burr, research associates at the Massachusetts Institute of Technoiogy, for specialised war-time applications. At the end of the war the inventors established Instron Engineering Corporation, Massachusetts, and Instron test equipment rapidly achieved world-wide fame. The number of Instron machines installed in Great Britain is growing rapidly, and the new United Kingdom factory was established—with the full co-operation of the Board of Trade—to supply British, Commonwealth and European markets. The managing director of British Instron, Ltd., is Mr. G. G. Zahler, who graduated in electrical engineering at Manchester University, and then worked in the field of scientific

instrumentation in the United States, on the Continent and in this country.

Two basic Instron models measure tension, compression, hysteresis and elastic modulus of virtually all materials, including all metals, plastics, natural and synthetic fibres, rubber, textiles, wood, paper, glass, etc. Associated equipment includes rheometers for the study of flow behaviour in polymer melts, electronic integrators and XY recorders, and set-ups for radioactive testing.

Kanigen Plating by Fescol

ALBRIGHT & WILSON (MFG.), LTD. announce that they have granted to Fescol, Ltd., a sub-licence for the operation of the Kanigen electroless nickel plating process. Fescol, Ltd., are planning to erect the necessary plant at their works at Brownhills, Staffs. Kanigen chemical nickel plate is a nickel-phosphorus alloy containing about 8% phosphorus. It has extremely low porosity and is hard (1,000 V.P.N. after heat treatment) and corrosion and wear-resistant. On ferrous materials the plate prevents contamination of liquids by iron from pumps, pipework and containers. Expensive alloys can often be replaced by Kanigen-plated steel or aluminium. It is claimed that the plating solution deposits a continuous and completely uniform plate on the most complex components. Kanigen is recognised both by the Ministry of Aviation and by the Air Registration Board by whom it has been approved under D.T.D. 900/4505 and A.I. 5112/57 respectively.

Cassiterite Crystals Find

WHEN the early 19th century Kenyon collection of rare British minerals was being prepared for sale recently two groups of cassiterite crystals were discovered in a jammed drawer, among them some specimens of unusual size and beauty, having the form and appearance of a perfect gem stone. The crystals were acquired by Professor S. Tolansky, F.R.S., professor of physics in the University of London, who has been Consultant in Physics since 1948 to the Tin Research Institute.

One of the individual crystals, originating from a Cornish mine, was the size of a two-carat diamond, deep yellow in colour, semi-transparent, and as hard as crystal quartz. Professor Tolansky had it mounted on a tie-pin without cutting, as its natural shape could not be improved upon—and presented the tie-pin to Dr. E. S. Hedges, Director of the International Tin Research Council, as an appreciation both of their association in the field of tin research, which has extended over many years, and as an acknowledgment of the frequent valuable help given by Dr. Hedges to his research students.

100 ton Arc Furnaces

BIRLEC-EFCO (MELTING), LTD., have received an order from the English Steel Corporation, Ltd., for two 100 ton arc furnaces for the new Tinsley Park Works, Sheffield. Each will have a nominal electrical rating of 35 MVA, and shell diameter of 22 ft. The furnaces will have rotating bodies and stainless steel bottoms to enable the fitting of magnetic stirrers. Birlefco Amplidyne electrode control with pneumatic counter-balance and a recently developed novel method of low reactance connection are to be included in the construction. The main circuit breakers will be designed and manufactured at the A.E.I. Rugby Works and will incorporate "on-load" tap change gear.

For Clyde Alloy Steel Works, Ltd., a similar furnace of 100 ton capacity and 22 ft. shell diameter, but having a nominal electrical rating of 25 MVA, is to be installed at the company's Hallside Works. In this installation the transformer will be of English Electric manufacture with "on-load" tap change gear, whilst the main circuit breaker will be an English Electric air blast unit.

Personal News

MR. E. L. MORGAN, formerly works metallurgist, has been appointed chief metallurgist of Workington Iron and Steel Co., a branch of The United Steel Cos., Ltd. MR. A. G. HOCK, formerly research manager, has been appointed metallurgical consultant at Workington.

MR. T. RICHMOND has been appointed to the board of The Titanic Steel Co., Ltd., a subsidiary of Samuel Osborn & Co., Ltd.

MR. W. KEEN took office as president of The Electric Steel Makers' Guild on 1st May, 1961, with MR. R. S. HOWES as vice-president and MR. F. CRANKSHAW as secretary.

AT the annual general meeting of the Drop Forging Research Association, MR. R. BENNETT (Smethwick Drop Forgings, Ltd.) was re-elected to the council, and the following new councillors were elected: MR. H. G. BOWN (Firth-Derihon Stampings, Ltd.), MR. W. E. A. REDFEARN (English Steel Forge & Engineering Corporation, Ltd.), MR. D. B. RUSSELL (Smith & Sons of Saltley, Ltd.) and MR. J. SHAKESPEARE (J. Shakespeare & Co., Ltd.). At a subsequent council meeting, MR. J. H. SWAIN (Stampings Alliance, Ltd.) was elected chairman of the council in succession to MR. W. E. GOLCHER, and MR. R. K. JOHNSON (Forgings & Presswork, Ltd.) and MR. A. L. STUART TODD (National Association of Drop Forgers and Stampers) were co-opted to the council.

IN consequence of a series of appointments announced by the Steel, Peech & Tozer branch of The United Steel Cos., Ltd., MR. C. H. HAYTER, works manager (Templeborough), is now works manager (Ickles departments and bar mills); MR. R. SCHOLEY, works manager (Ickles), is works manager (flat products); MR. R. S. HOWES, manager of the *Spear* project, is works manager (steelmaking and primary mills); MR. P. BENYON, works manager (operational research and work study), is personnel manager; DR. B. B. HUNDY, chief research metallurgist, is chief metallurgist; MR. W. ASH, chief works metallurgist, is deputy chief metallurgist; MR. H. A. LONGDEN, assistant chief works metallurgist, is works metallurgist; and MR. M. THOMAS, works manager (services), is general services manager.

MR. C. J. BUCHANAN-DUNLOP has been appointed manager of the Birmingham area sales office of Alcan Industries, Ltd., in succession to MR. D. W. TAYLOR who is to take over management of the London area sales office later this year.

THE appointment is announced of two new directors of I.C.I. metals division, MR. T. H. GALLIE (Overseas) and MR. J. R. H. CRANE (copper products). Mr. Gallie has

been concerned with metal sales throughout his twenty-five years' service with the company and for the past two years has been metal sales manager, Midland region. Mr. Crane joined I.C.I. metals division as laboratory assistant in 1939 but quickly developed a bent for the technical side of metal production. After two years as titanium production manager, he was transferred in 1959 to Lightning Fasteners, Ltd., Witton, as general manager.

ASSOCIATED ELECTRICAL INDUSTRIES, LTD., has appointed MR. R. F. MARSHALL as central education manager and MR. D. BAIRD as central personnel manager.

MR. D. W. HAMMOND has retired as a director of Jessop-Saville, Ltd., the steel-making organisation of the B.S.A. group of companies. Mr. Hammond joined B.S.A. in 1917 as assistant chemist, and six years later transferred to Jessop-Saville as chief chemist and metallurgist. In 1932, he was made assistant works manager and in 1936 he became works manager. He was appointed to the local board in July 1942 and was elected a director of Jessop-Saville, Ltd., in 1959.

MR. F. R. SWINDEN, works manager of The Sheffield Wire Rope Co., Ltd., has been appointed an executive director of the company, a member of the Firth Cleveland group.

MR. S. SHAW, M.B.E., welfare and safety officer of George Kent, Ltd., was recently, on the occasion of his retirement, presented by the company chairman, Commander P. W. Kent, R.N., with a cheque subscribed to throughout the firm.

MR. O. F. GRAZEBROOK, J.P. and MR. J. TENNENT, J.P., D.L., following their retirement from the board of The British Rollmakers Corporation, Ltd., have been appointed joint honorary presidents of the Corporation.

MR. R. T. MILLER has been appointed managing director, and MR. A. GEORGE assistant managing director, of Fletcher Miller, Ltd., a member of the Castrol group of companies. Both are also directors of Castrol Industrial, Ltd., another member of the group.

HILGER & WATTS, LTD., have appointed two new representatives—MR. A. CAMPBELL for Scotland and Dr. E. R. SAYER for the Midlands. Mr. Campbell can be contacted at the offices of Elesco Electronics, Ltd., 2 Fitzroy Place, Glasgow, C.3. (Tel: Central 1082); and Dr. Sayer at 32 Mountford Crescent, Aldridge, Nr. Walsall, Staffs. (Tel: Aldridge 53151).

THE RT. HON. LORD CLITHEROE, P.C. has been appointed a vice-chairman of Tube Investments, Ltd. SIR BEN LOCKSPEISER, K.C.B., F.R.S., having reached retirement age, and SIR FRANCIS DE GUINGAND, K.B.E., C.B., D.S.O., have resigned from the board as from 30th April, 1961. Sir Francis is returning to the Union where he will continue to be in charge of T.I.'s interests in Southern Africa. DR. J. M. KAY, at present professor of nuclear power at the Imperial College of Science and Technology at the University of London, has been appointed to the board of Tube Investments, Ltd., as director of research and development, from 1st July 1961.

MR. W. E. BARDGETT, research manager in the research and development department of The United Steel Cos., Ltd., will retire from this position on 1st July but will remain with the department as a consultant. DR. K. J. IRVINE, at present deputy research manager, will succeed Mr. Bardgett with the title of metallurgical research manager.

JESSOP-SAVILLE, LTD., of Sheffield—a member of the B.S.A. group of companies—announce the appointment of MR. G. T. HARRIS as assistant managing director. He has been with the Jessop-Saville organisation for more than twenty years and has done notable work in connection with high temperature steels and the production of vacuum-melted steels and titanium alloys. Jessop-Saville also announce the appointment to the board of MR. J. G. RYDER, who recently joined the company to take complete charge of production.

MR. C. E. WRANGHAM has retired from the boards of Davy-Ashmore, Ltd., and its subsidiaries.

MR. E. T. SARA has been appointed assistant general sales manager of The United Steel Cos., Ltd. He will be responsible for the district sales offices in the United Kingdom, as well as for the commercial research, public relations and publicity departments.

MR. W. E. HUGHES has been appointed director and general manager of British Industrial Gases, Ltd., in succession to MR. F. BLACKMORE who is now manager of equipment development, technical division, The British Oxygen Co., Ltd. Mr. Hughes is succeeded as sales manager of B.I.G., by MR. L. H. PIERSON, formerly field manager.

Obituary

WE regret to record the death of the following:

EMERITUS PROFESSOR J. H. ANDREW, professor of metallurgy and dean of the faculty of metallurgy in the University of Sheffield from 1932 to 1950, who died on 5th May, 1961, at the age of 74. A graduate and later research fellow of the University of Manchester, he was in charge of the metallurgical research department of Sir W. G. Armstrong-Whitworth & Co., Ltd., from 1914 to 1920, when he was appointed to the chair of metallurgy at the Royal Technical College, Glasgow in succession to Dr. C. H. Desch. When the latter left Sheffield in 1932, Dr. Andrew again succeeded him as professor of metallurgy. One of the most distinguished metallurgists and teachers of metallurgy of his generation, he was in 1949, awarded the Bessemer Gold Medal of the Iron and Steel Institute, of which he had been a member since 1911 and a member of council since 1941 Dr. Andrew was a founder member of the Institution of Metallurgists, an original member of the Institute of Metals, and a past-president of the Institute of Vitreous Enamellers.

MR. J. W. RYDE, chief scientist of the Hirst Research Centre of The General Electric Co., Ltd., who died on 15th May, 1961, at the age of 63. He joined the newly established G.E.C. research laboratories as a physicist in 1919, and was a leading member of the scientific staff of the laboratories from the start. He had much to do with optical systems, and a pocket illumination chart for service use—designed in his leisure hours— was used extensively in military operations. He was appointed chief physicist in 1950 and chief scientist in 1953. During these recent years he has had overall responsibility for the programmes of pure scientific research of the establishment, with particular interests in the fields of new materials, crystal growing, and solid state physics.

Canteen Catering

As in every other industry, the main factors governing the economics of the catering business are: quality of product, cost of production, and well-being of workpeople. Electricity measures up well to these three essential factors.

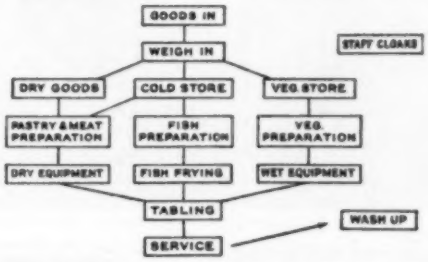
The outstanding virtue of electricity is better cooking, particularly in roasting and pastry ovens where high quality is more easily maintained than in ovens using other forms of heat. The cost of production varies somewhat with the type of food and the size of the establishment, but is usually between $\frac{1}{2}$ and $\frac{3}{4}$ of a unit of electricity per meal. Cleanliness of electric cooking is axiomatic and provides better working conditions for the staff.

The actual size of the kitchen is influenced greatly by its shape and by the number of people catered for, but a rough guide is as follows:

KITCHEN TO DEAL WITH	SIZE
up to 100 persons	5-6 sq. ft. per person
100-250 persons	4-5 sq. ft. per person
250-1000 persons	3-4 sq. ft. per person
over 1000 persons	3 sq. ft. per person

Design

Where the kitchen is designed from the start for the full use of electricity, planning is simplified as the equipment can be placed where it is required without reference to the need for flues.

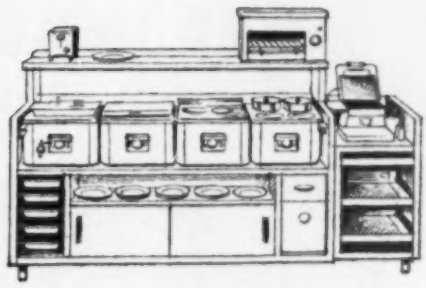


If an existing kitchen is already using other types of cooking equipment, however, electrical equipment can still be introduced item by item to bring increasing benefits.

Quick-service Equipment

The popularity of the quick-service establishment where the food is cooked at the service counter in the full view of the customer is steadily growing, and this type of catering can readily be provided in the canteen by the installation of a Back Bar cooking unit, installed behind a section of the service counter.

The popularity of the mid-day joint and two vegetables is on the wane and the really up-to-date

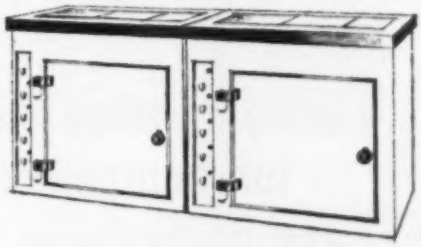


canteen should provide the welcome alternative of fresh food cooked on the spot.

Electric Catering Equipment

Electric catering equipment covers every single kitchen activity and some of the appliances in common use are:

COOKING. Ranges, boiling tables, steaming, roasting and pastry ovens, vegetable boilers, fryers, griller/toasters.



SERVICE AND WASHING-UP EQUIPMENT. Bains-marie, hot cupboards, tea and coffee machines, washing-up machines for the larger kitchen and sterilising sinks for the smaller, refrigerated cold-service counter and display cabinets, soda fountains.

PREPARATION. Mixing machines with attachments for chopping and mincing etc., potato peeler, slicing machine.

QUICK-SERVICE EQUIPMENT. Infra-red (contact) grill, automatic toaster, griddle plate, automatic fryer, boiling plates, soup heaters, etc., and, of course, the indispensable refrigerator.

For further information, get in touch with your Electricity Board or write direct to the Electrical Development Association, 2 Savoy Hill, London, W.C.2.

Excellent reference books on the industrial and commercial uses of electricity are available—"Electric Commercial Catering Handbook" (5/-, or 5/6 post free) is an example.

E.D.A. also have available on free loan in the United Kingdom a series of films on the industrial uses of electricity, including commercial catering. Ask for a catalogue.

12799

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W.B. 101

RECENT DEVELOPMENTS

MATERIALS : PROCESSES : EQUIPMENT

High Strength Steel

A NEW 18% nickel alloy steel*, claimed to have unmatched toughness at the highest strength levels of traditional alloy steels, has been developed in the Bayonne, N.J., laboratories of The International Nickel Co., Inc., and it is believed that this discovery paves the way for a new family of high strength "mar-aged" steels with advanced engineering design possibilities for applications involving exceptionally high pressure and stress. Outstanding characteristics are the ability to achieve a yield strength of 250,000 lb./sq. in. (110 tons/sq. in.) while maintaining a nil ductility temperature below −80° F.; a notch tensile strength exceeding 400,000 lb./sq. in. (180 tons/sq. in.) with a 0·0005 in. notch radius; and a high resistance to stress-corrosion cracking.

The new steel has a nominal composition of 18% Ni, 7% Co, 5% Mo and less than 0·5% Ti, with a maximum of 0·05% carbon. Higher and lower tensile strengths can be obtained by modification of this basic composition, and there are indications that strength levels of up to 500,000 lb./sq. in. (220 tons/sq. in.) or even higher may be achieved in this type of steel. The properties of steels of this type are achieved by "mar-ageing", a process involving age-hardening of martensite. With proper finishing temperature at the mill followed by cooling to room temperature, the treatment consists merely of holding for about three hours at 900° F. (480° C.) and air cooling. Solution annealing at 1,500° F. (815° C.) prior to mar-ageing is optional. Quenching is not required and full properties can be developed in heavy sections with no distortion problems.

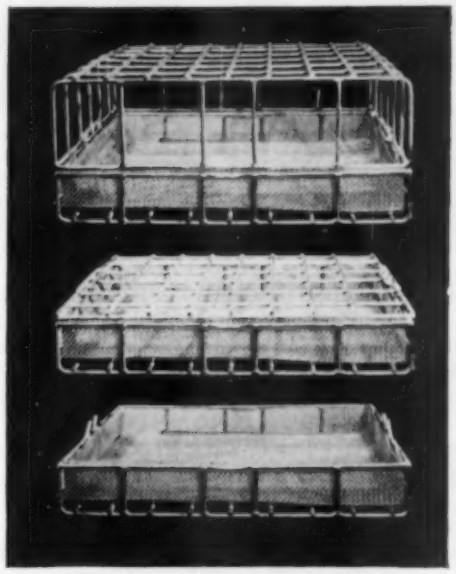
A 10 ton commercial heat has been produced by air melting in an arc furnace, and ingots as large as 23 in. × 42 in. from this heat have been rolled into plate on conventional steel mill equipment. The new steel can readily be produced in all commercial shapes, and its low work hardening tendency permits extensive cold forming operations to be carried out on it. It can be successfully welded without preheating, post-weld mar-ageing restoring the heat-affected zone to full strength and establishing in the weld metal properties closely approaching those of the base plate.

The International Nickel Co. (Mond), Ltd., Thames House, Millbank, London, S.W.1.

* U.S. Patent applied for.

Heat Treatment Basket Grids

IPSEN INDUSTRIES, INC., has developed special grids to be used with the company's standard line of heat treatment baskets. The fixtures are designed to hold long pieces or unusually-shaped material during heat treatment. Both baskets and fixtures are built to allow maximum heating or quenching rates for the material while permitting maximum net payloads in each charge. The heat treatment basket fixtures are made of highly heat resistant materials to maintain strength under extreme temperature changes and to resist atmosphere contamination, and pressure resistant welding gives increased strength at all critical points. The height of the grid and the size of the openings can be varied to fit customer requirements. The grid is anchored by using the stacking feature of the heat treatment basket, a sleeve-like opening of the grid fitting over the looped end pieces of the basket to prevent the grid from sliding in any direction.



Ipsen heat treatment basket grids.

Ipsen Industries, Inc., 53 Victoria Road, Surbiton, Surrey.

Reciprotor Vacuum Pump

EDWARDS HIGH VACUUM, LTD., have been appointed sole agents, for the United Kingdom and Commonwealth, for the new Reciprotor combined vacuum/pressure pump manufactured in Denmark. Operated by an electromagnetic vibrator, there are no rotating parts as all movement is in an axial direction. The pump is claimed to be unique in a number of features, including its very compact design, a weight of only 10 lb., and a completely oil-free air delivery as no lubrication is necessary. The pistons are fitted with specially treated self-lubricating nylon rings which slide in hardened, ground and polished steel sleeves. The rib-cooled cylinders, the pistons, and the housing are entirely of light metal; the permanent magnets are of special steel; and all components are cadmium plated, nickel plated, impregnated or varnished for protection.

The Reciprotor is available in two versions. The type 406G is designed for continuous operation and provides a free air displacement of 1·62 cu. ft./min., a vacuum of

The Reciprotor vacuum pump.

18 in. Hg, and a maximum pressure of 7·8 lb./sq. in. The type 606G is rated for intermittent operation only, but has an improved performance, delivering air at 1·77 cu. ft./min., and attaining a vacuum of 22 in. Hg and a maximum pressure of 10·7 lb./sq. in.

Edwards High Vacuum, Ltd., Manor Royal, Crawley, Sussex

Electric Measuring and Control System with True Two-Wire Working

HONEYWELL CONTROLS, LTD., are now marketing a new electric measuring and control system with true two-wire D.C. transmission. Described as fully integrated instrumentation, the equipment is of completely original design embodying modular principles. It is known as the ElectriK Tel-O-Set system and is believed to be the first two-wire transmission instrumentation to emerge. Direct current transmission of the signal at 4–20 mA. is used along a pair of wires that also carry the 42 V. D.C. power supply. There are no field power connections and shielding of the transmission wires is not required. Suitable for any of the usual industrial process control duties, the ElectriK Tel-O-Set system provides many modes of control including, 'proportional plus reset plus rate action.'

The basic system comprises a transmitter, a 5½ in. × 6 in. receiver-controller and a valve operator. The variety of standard alternative units is considerable and includes circular scale as well as strip chart controllers, simple recorders, millivolt-to-current transmitters, process-pressure-to-current transmitters, differential pressure-to-current transmitters, transducers for standard pneumatic-to-electric signals and vice versa; additionally, the control unit with the Tel-O-Set recorder may be arranged for front-of-panel or back-of-panel adjustment. All these units are fully transistorised. All field units operate on the force-balance principle and can be used in ambient temperatures of –40° F. to 150° F. The recorder instruments have a 6-month ink supply, daily chart tear-off, and 30-day rewind. Process and external electrical connection to field-mounted transmitters are isolated from inside the case for convenience in maintenance.

The ElectriK Tel-O-Set system will find its applications in chemical, petroleum, electricity supply, nuclear, steel, water treatment, and other industries and research. Honeywell Controls are to supply their first big scheme of this kind for the 720-mile northern Indian pipeline for Oil India Pte., Ltd., this year.

Honeywell Controls Ltd., Greenford, Middlesex.

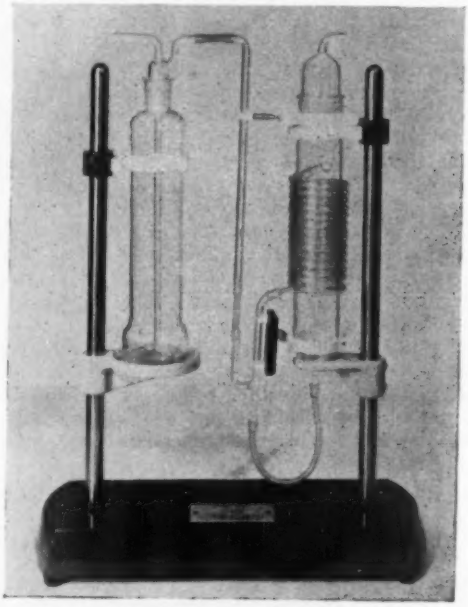
Seam-Welding Blanks

JOHNSON MATTHEY announce that a wider range of rough-machined seam-welding wheel blanks in Mallory 3 can now be supplied from stock. In the interests of international standardisation, the blanks are now available in metric sizes, as recommended in B.S. 3067. The new range includes all the commonly used sizes listed in the specification, and the metric sizes are very close to the superseded inch sizes. Details of the new range of sizes are given in leaflet 7200/3, "Resistance Welding Electrode Materials."

*Johnson, Matthey & Co., Ltd., 73-83 Hatton Garden, London, E.C.*1.

Improved Nilox Apparatus

THE Southern Analytical Nilox apparatus is now available in a new and improved form. It has been designed to remove safely oxygen from gases such as argon,



The Nilox gas purifier.

hydrogen and nitrogen. For example, a typical oxygen content in ordinary commercial nitrogen is 2,000 p.p.m., but after purification with the Nilox the figure is 0·2 p.p.m. Nilox contains no electrical or moving parts, its chemical reagents are continuously regenerated, and it will deal with flow rates up to 20 litres per hour.

Southern Analytical, Ltd., Frimley Road, Camberley, Surrey.

CURRENT LITERATURE

Book Notices

MEASUREMENT OF LOAD BY ELASTIC DEVICES

Published for the Department of Scientific and Industrial Research by H.M. Stationery Office. 3s. (by post 3s. 4d.); U.S.A. 54 cents.

THE development of accurate elastic devices was first prompted by the need for a convenient means of verifying machines for testing materials in tension and compression. Other uses for elastic devices now include the measurement of forces applied to experimental structures and the thrust of jet engines and rockets. They are now also being very extensively used as weighing units in industry, ranging from portable units for weighing aircraft, to built-in units for weighing large storage hoppers and silos.

This latest addition to the N.P.L. series "Notes on Applied Science," deals with the measurement of load by elastic devices. The Note defines the technical unit of force used when elastic devices are calibrated and outlines the facilities available at the National Physical Laboratory for their calibration. Descriptions and comments about their use are given for the more common types of elastic devices such as proving rings, standardising boxes, hydrostatic load capsules and electrical resistance strain gauge load cells. Guidance is also given on the accuracy of load measurement which can be expected from many of these. Two final sections deal with temperature corrections and methods of plotting the calibration results graphically, thus permitting interpolation between calibration loads and the accurate transfer from one system of units of force to another.

HALDEN BOILING HEAVY WATER REACTOR PROJECT

SECOND ANNUAL REPORT

151 pp., 51 illustrations, sketches and graphs. Published by the O.E.E.C. European Nuclear Energy Agency. Obtainable from H.M. Stationery Office.

THE O.E.E.C. Halden Reactor Project was established in 1958 by an agreement which provides for its governing body to report to the Steering Committee of the O.E.E.C. European Nuclear Energy Agency (ENEA) on the general progress of the work of the Project. The first report covered the initial sixteen months of joint operations during which the international staff was built up, the research programme finalised, and the reactor commissioned and brought critical. The present report deals with the subsequent fourteen months to the end of 1960.

The reactor, which is situated at Halden in southern Norway, is owned and operated by the Norwegian Institutt for Atomenergi (IFA), which bears the full responsibility for reactor safety, although international specialists from the signatory countries participate in reactor operation. The principal objectives of the present programme are to provide experience in the operation of a heavy boiling water reactor, to establish an understanding of the physics and dynamics which govern its performance, and to develop means of accurate measurement within the core.

The reactor first became critical in June, 1959, and an initial series of low-power experiments was completed by January, 1960, when the reactor was shut down to enable checks and modifications to be carried out before continuing with further experiments at high power. The fuel elements were repaired to remedy the effects of corrosion, the heavy water purification system modified, and the leak-tightness of the reactor hall improved. The reactor was started-up again in August, 1960, and achieved boiling for the first time on 5th October, at 3 MW.

Joint operation of the reactor is spread over two periods, during the first of which it will function at 5 MW. with a natural uranium fuel charge. During the second period, which is due to begin at the end of this year, the reactor will be brought up to its maximum rating of 20 MW. with an enriched uranium second fuel charge.

The present publication covers not only the technical progress achieved during the period under review, but also gives a full detailed description of the reactor installation and the general administration of the Project. The report is in six sections, of which the first surveys briefly the historical background of the Project, its structure and objectives, and a number of administrative details, including staff organisation, contracts policy, arrangements covering information and patents resulting from the experimental work, and finance. The other sections cover the reactor design and construction, fuel, reactor operation, safety organisation, and the research programme. There is also a list of reports published on the Project.

Trade Publications

THE Super Permo electrical iron featured in a new leaflet issued by Samuel Osborn & Co., Ltd., is a high quality product comprising 99·7% pure iron which possesses high magnetic permeability with low remanence and coercive force properties, which are essential in electromagnetic parts where high magnetic induction is required. The leaflet gives details of composition and heat treatment and presents the results of magnetic tests on the material before and after annealing. Reference is also made to the machining of this material and to suitable applications. It is available as bars, wire, forgings, plates and strip, special sections and castings.

FOR almost half a century, Lectromelt furnaces have been prominent in the electric melting and smelting field, the makers having pioneered developments such as top charging, power operated electrode holders, oversize roof rings for improved roof life, etc. Now G.W.B. Furnaces, Ltd., of Dudley, Worcs., are able to offer these furnaces and their services to concerns in the United Kingdom and certain British Commonwealth countries, and a new illustrated brochure has recently been introduced by the company showing the salient features of the furnaces and associated handling equipment. G.W.B.-Lectromelt furnaces range in capacity from 200 lb. to 200 tons and include submerged arc types.

M. R. TRUMUL is a firebrick of true mullite composition, in which there is no free silica. The structure consists of massive interlocking mullite crystals together with a small percentage of corundum. These bricks can be safely used in ordinary furnace walls with hot face temperatures as high as 1,760° C., and a leaflet recently issued by the makers, Morgan Refractories, Ltd., gives details of typical properties, and shows the effect of excess silica on deformation under load at temperature.

SPECIFICATION SHEET SS.010, recently issued by George Kent, Ltd., deals with Commander air-operated receiving instruments, which are Bourdon-tube operated unless a tractor-wheel type integrator is specified, in which case a mercury-U-tube-operated instrument is supplied. Instruments available in this series include circular-chart recorders, circular-chart recorder/controllers, sector-scale indicators, sector-scale indicator/controllers and circular-scale indicators, and the leaflet gives full specifications including dimensions and mounting details.

ABSTRACTS of papers presented at the 47th Annual Technical Proceedings of the American Electroplaters' Society (which reflect, in particular, work on methods of improving the corrosion-resistance of nickel/chromium electrodeposited coatings) form an interesting feature of the March issue of *The Nickel Bulletin*. In the section covering literature on the production, properties, fabrication and applications of heat- and corrosion-resisting alloys and steels, items on stress-corrosion cracking (including a comprehensive survey of the subject by the American Society for Testing Materials) are worthy of particular note. Low-temperature tests on pressure vessels fabricated from 9% nickel steel in various conditions of heat treatment are among the investigations referred to in the section of the issue concerned with structural steels, and in the general section attention is drawn to a compilation of data on the low-temperature properties of various high- and low-alloy nickel-containing alloys and steels.

WE have received from the Incandescent Heat Co., Ltd., leaflet No. FP.5 showing the wide use of Whiting dust arresters on cupolas. These are manufactured by the Incandescent foundry plant division in association with the Whiting Corporation of America. The division also makes other Whiting equipment, including hot metal receivers, chargers, hot blast heaters, cupolas, and ladles.

AN interesting article in the April 1961 issue of *Finishing Facts*, the I.C.I. paints division publication, describes the production of painted metal strip at the works of Metalon Steels, Ltd., of Willenhall, Staffs. This material is intended to speed up production and it is said to be capable of being formed without damage to the coating so long as the tools are in good condition. Other articles deal with nylon-sheathed copper wire, finishes for textile machinery, and the use of impregnating varnish in the production of electric traction motors.

THE Pyrene range of de-rusting materials is featured in a new leaflet issued by the metal finishing division of The Pyrene Co., Ltd. These include Preperite No. 1 and Preperite No. 3, uninhibited and inhibited rust removing solutions, respectively, Paste Preperite suitable for spot de-rusting, and Pyroclean No. 201 which may be used as a de-rusting solution or for the removal of scale and sludge formed on heating coils in Bonderizing and Parkerizing plants.

FOR the first time since Associated Electrical Industries, Ltd., began trading as a single entity, it has been possible to review the work and progress of its engineering divisions and trading companies. This has been done in a new publication in which the review is divided into four main sections—generation and supply, industry and commerce, transport, and science and medicine, each of which contains material likely to be of interest to readers in the particular field. In previous years this material has appeared in the house organs of the individual companies, particularly in the *M-V Gazette* and *B.T.H. Activities*.

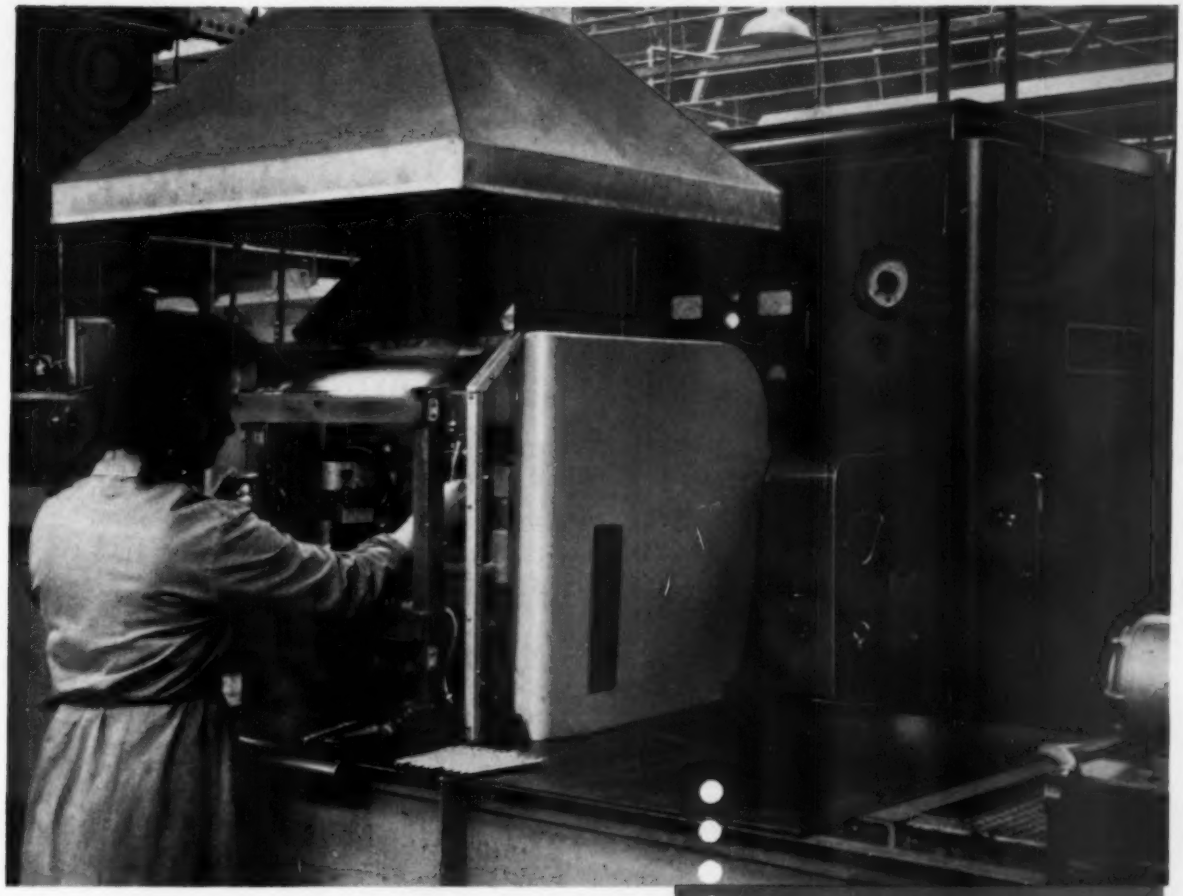
GR '341' dolomite bricks, first made by General Refractories, Ltd., in 1938–39 as a "wartime" measure, have since found extensive use in basic electric furnaces and basic bessemer converters, and improved production methods have made possible the extension of their use to other fields. A new leaflet issued by the company gives the standard sizes, chemical analysis and physical properties, together with illustrations of their use.

AN article describing some of the factors involved in the production of plastics components by the injection moulding process is a highlight of the April/June issue of *The Forge*, quarterly journal of the Brockhouse organisation. Also included is this issue is 'Highway to Vehicle Recovery and Service,' a feature which tells the story of the pioneer work carried out by Harvey Frost & Co., Ltd., a member of the Brockhouse group, in the development of modern garage servicing equipment.

THE article most likely to be of interest to readers of METALLURGIA in the April 1961 issue of *A.E.I. Engineering* is one describing a new hot reversing mill for aluminium. This is the 144 in. wide mill, recently commissioned at the Rogerstone Works of Alcan Industries Ltd., which was described in our November 1960 issue. The present article describes the electrical equipment in a more detailed manner. Other articles deal with British commercial nuclear power today; a computer for commerce and industry; improved dielectrics produced by means of high-energy radiation; and recent developments in adsorption drying.

REFERENCE is made in the Spring 1961 issue of *Turnbridge News*, to the use of a Holmes inert gas generator installed at Swansea for purging a zinc/lead blast furnace condensation system of carbon monoxide before opening up for maintenance purposes. Other technical items deal with the butane/air plant at Hereford and the inert-gas fire-extinguishing system on the *Oriana*. Copies may be obtained from W. C. Holmes and Co., Ltd., Turnbridge, Huddersfield.

WE have recently received a copy of the English edition of the first issue of the *Bulletin of the European General Galvanizers Association*: French, German and Italian editions are also being published. The *Bulletin* is intended for users of galvanized steel and in each issue some of the more important fields of application will be reviewed. In this first issue, the main articles dealing with railway applications, with steel framed buildings, and with progress in the galvanizing industry, have been contributed by Dutch, Italian and German authors. A news section briefly describes and illustrates a number of unusual applications. The *Bulletin* is issued free of charge: application should be made to the Zinc Development Association, 34 Berkeley Square, London W.1.



Wild-Barfield A.H.F. equipment is used by Wolf Electric Tools, Ltd., (manufacturers of the well-known Wolfcub drills etc.), for the hardening and tempering of small gears, shafts and pinions. Many other industrial concerns have found that Wild-Barfield A.H.F. induction heating speeds production, saves space and offers savings all along the line. Our engineers will be glad to supply further details and explain how Wild-Barfield A.H.F. equipment can help you.

WILD-BARFIELD A.H.F. equipment at WOLF ELECTRIC TOOLS LTD

WILD BARFIELD A.H.F.

Induction heating speeds production

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WB 64

LABORATORY METHODS
MECHANICAL · CHEMICAL · PHYSICAL · METALLOGRAPHIC
INSTRUMENTS AND MATERIALS
JUNE, 1961 Vol. LXIII, No. 380

An Improved Tensile Testing Apparatus

By N. C. Balchin, B.A., and B. L. Mordike,* B.Sc.

(Research Laboratory for the Physics and Chemistry of Solids, University of Cambridge)

A method of tensile testing is described in which accurate indication of load is obtained by the use of a compliant spring, and in which the strain-rate is maintained constant as if an infinitely stiff spring were employed.

CONVENTIONAL tensile testing apparatus consists essentially of a specimen and a spring carrying the same load. The assembly is stretched at a constant rate by a motor drive, and the elastic deformation of the spring gives a measure of the stress. The result of the test may vary with the division of extension between the spring and the specimen. With a compliant spring, nearly all the extension occurs there, and a constant rate of increase of stress is approached, while a stiff spring imposes a nearly constant strain rate on the specimen.

The effect of strain rate on yield strength and on ultimate strength is not normally very marked at room temperature, but at higher temperatures appreciable differences occur ; for example, an increase can raise the whole stress-strain curve to higher stress values. For results to be strictly comparable it is necessary to define closely the conditions of test, especially in regard to constancy of stress-rate or strain-rate.

At high temperatures materials deform mainly in the plastic mode at a low load. Consequently, if an accurate indication of load is to be obtained, a compliant spring must be used. A method is described below in which a compliant spring is used, and in which the strain-rate is maintained constant as if an infinitely stiff spring were employed. To achieve this, the deflection of the spring is "backed-off," by an externally-imposed movement of its free end, so to maintain one end of the specimen in a fixed position (Fig. 1). A constant strain-rate is obtained simply by pulling the other end at a constant speed.

The rotation of the servo motor is proportional to the stress and that of the constant-speed motor to strain, so they may be used to drive a stress-strain curve tracer. A suitable detector element is a resistance strain gauge on a bow spring. The above system may seem to be of much greater complexity than the conventional one : this is not so if a self-balancing recording instrument is used, as may be necessary for apparatus working in a vacuum (Fig. 2).

* Dr. Mordike is now CIBA Research Fellow at Institute for Metallphysik, Göttingen, Germany.

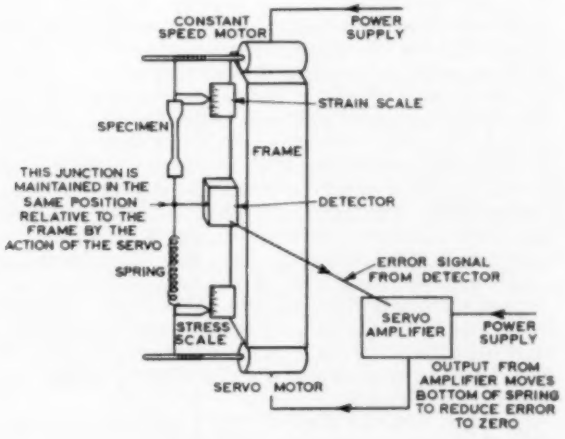

Fig. 1

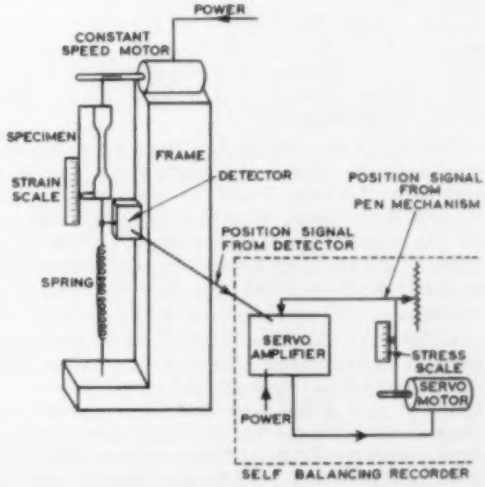

Fig. 2

Since the extension of the specimen can now be satisfactorily defined, a constant rate of increase of true strain may be imposed, should this be desirable for any particular investigation. This could be done by use of a cam driven by a constant-speed mechanism, or of another servo of a modified velodyne type. By simply exchanging the positions of spring and specimen (or the electrical connections to the motors if these are of the same type), a constant strain rate in the spring, and hence a constant stress rate in the specimen is obtained.

A constant stress for the study of creep may be achieved by omitting the constant-speed motor: the system will automatically correct any variations from the desired condition due to the creep of the specimen, etc.

A similar system could be applied to other tests where the result is affected by the compliance of the measuring device, for example in determinations of coefficients of friction.

Acknowledgments

We should like to thank the U.K.A.E.A. and Tube Investments, Ltd., respectively, for maintenance grants and our respective supervisors, Drs. Tabor and Bowden, for their encouragement.

Exhibits of Metallurgical Interest at the Physical Society Exhibition

(*Continued from page 262 of the May issue*)

Differential Cathode Ray Polarograph

THE Nashton differential cathode ray polarograph is a production version of the equipment developed by H. M. Davies, H. J. Shalgosky and J. E. Seaborn, of the U.K. Atomic Energy Authority, Woolwich. The final prototype was shown on the U.K.A.E.A. stand at ACHEMA (the German Chemical Plant Exhibition) at Frankfurt-on-Main, 9th-17th June, 1961.

This new instrument, made by Nash & Thompson, Ltd., can be used as an analytical tool for chemical and metallurgical examinations of many kinds. It has two identical polarographic cells, which can be used separately or together. There are synchronising devices which ensure that both mercury-drop cathodes grow and fall simultaneously in twin cell operation. The two cells are housed in an airtight Perspex chamber, through which a flow of nitrogen is maintained. Nitrogen is also bubbled through the cells themselves before a determination is carried out, to eliminate effects due to dissolved oxygen in the solution. The cells are fed through tap funnels and exhausted by vacuum suction, so that the working solutions can be removed or replenished without opening the chamber. Mercury can be drained from the cells by means of a separate tap.

The D.C.R.P. is claimed to have a greater maximum resolving power than the normal cathode ray polarograph, and to be between 7 and 10 times more sensitive in single cell operation. This is mainly due to the provision of 'base line slope compensation,' whereby residual currents due to earlier reductions can be cancelled by the application of a small opposing current (maximum 0·1 mA.).

Using two cells, the D.C.R.P. is between 1 and 50 times more sensitive in 'derivative' operation, depending on the resolution required, and 10–11 times more sensitive by the subtractive method; specially purified reagents are not required. In comparative polarography, determinations with a coefficient of variation better than 0·2% are possible. Peak heights can be measured over a maximum height of 100 mm. to an accuracy of ± 0·5%.

In derivative operation the trace approximates to the first algebraic derivative of the current wave form for a single cell. Time constant networks of 0·01 or 0·03 seconds can be used to obtain derivative displays of the wave forms produced in single cell, subtractive or comparative operation, and second derivative traces in derivative operation. The shorter time constant is used where the highest resolving power is required and the peak heights obtained with maximum sensitivity are about 8 times greater than with the ordinary cathode ray polarograph. With the longer time constant they are approximately 20 times greater.

High Temperature Heating Elements and Thermocouples

For heating furnaces to temperatures as high as 1,800° C., Metals Research, Ltd., have developed a new type of heating element—the Pyrotube—which consists of a molybdenum heater sheathed by a pure recrystallised alumina tube. The impervious sheath is sealed at the lower end and closed at the top by an appropriate header which contains the electrical terminals and the connections for the protective gas supply. Cylinder hydrogen, used at very low flow rates to prevent oxidation of the molybdenum, is confined within the Pyrotube. The heated zone starts 3 in. from the bottom and extends upwards for 6 in. or 12 in. in the two standard types. These robust, easily replaceable elements are capable of heating furnaces to 1,800° C. in oxidising or reducing atmospheres. The very low silica content (0·02%) of the sheath eliminates contamination of the charge.

Of similar construction are the Pyrosheaths—tungsten/tungsten-rhenium thermocouples enclosed in an alumina sheath with arrangements similar to those in the Pyrotube for maintaining the protective atmosphere and sealing the electrical leads. Pyrosheaths are suitable for continuous use at 1,800° C. (31 mV.) in oxidising and reducing atmospheres.

Pyrotube furnaces may be simply and inexpensively built in a wide range of shapes and sizes.

(*continued on page 318*)

The Use of the Inverted Microscope for Series Micro-Hardness Testing

An Application to Dilute Lead-Antimony Alloys

By E. J. Hooker, M.A., Ph.D.*

Unavoidable errors in micro-hardness measurements arising from incorrect counterpoising on inverted microscopes can be allowed for by including a standard test-piece within each specimen mount and measuring its hardness under the same conditions of balance. A multiplying factor can then be obtained to correct the hardness of the other specimens in the mount. An investigation employing this technique showed the linear increase in hardness with alloying additions of lead containing up to 0·8% antimony under equilibrium conditions at room temperature, and the distinct hardness curve of age-hardened specimens commencing at 0·2% antimony.

MICRO-HARDNESS testing can be conveniently carried out using an inverted microscope, and with the attachments available for the Vickers projection microscope[1] the only step between making an indentation and measuring it is refocussing the objective. A number of tests may be made quite quickly on a single specimen for the purpose of comparing hardness values at a number of points, such as between phases. Each specimen, however, has to be counterpoised individually before putting on the indentation load, and although it is claimed that the pivot bearings of the instrument are sufficiently free to permit balancing to be carried out with a sensitivity better than 100 mg., this can represent a substantial source of error when low loads of the order of 1 g. are used for soft materials.

It is often required to compare hardness values between specimens, and where these are of such size or number as to preclude their being mounted together within a single specimen holder, the source of error mentioned above can clearly lead to misinterpretation of the results. Nevertheless, it has been found possible to correct these errors if a small sample of a standard material can be included in each specimen mount. The hardness of this standard sample can then be measured under the same conditions of balance adjustment as the samples for examination and, by assigning a suitable constant hardness to all the standard specimens, a correction factor can be calculated for multiplying the hardness readings of all the specimens in each mount, thus producing a series of hardness values which may be compared directly with each other. A more detailed account of its application to a particular case will serve as a suitable example of this technique.

Micro-Hardness Testing of Lead-Antimony Alloys

The lead-rich end of the lead-antimony system[2] contains a region of α-solid solution with decreasing solid solubility of antimony in lead at the lower temperatures. These alloys are, in fact, age-hardening, and when they are solution treated and quenched, and then strained in excess of certain critical amounts, recovery on storing at room temperature is accompanied by the appearance, in the region of the original grain boundaries, of recrystallised areas containing particles of discontinuously precipitated antimony-rich material. It was desired to compare the micro-hardness of these regions with those of aged, unstrained areas, and to observe how these values were dependent on composition.

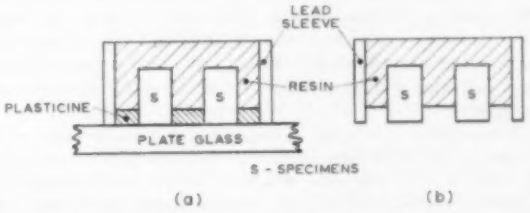

Fig. 1.—Sectional diagram illustrating specimen mounting for micro-hardness testing: (a) method of constructing mount; (b) completed mount.

Specimens were used which had become available from a previous investigation into this alloy field[2] and consisted of a range of lead-antimony alloys, containing less than 1% antimony, some of which had been strained by up to 10% and all aged at room temperature in excess of four years. A selection of these was made and portions of a number of strained and unstrained specimens containing 0·2%, 0·4%, 0·6% and 0·8% antimony were mounted singly or in pairs, each with a piece of standard unstrained pure lead cut from a common sample.

Due to the softness of the lead alloys used, certain difficulties were met in the metallographic preparation for micro-hardness testing of specimens mounted in the normal manner, and it was found advisable to arrange for the specimens to have their surfaces for examination standing proud of the mounting medium. This was effected by using a lead mounting sleeve which was placed on a plate-glass surface and the rough-ground specimens for examination arranged within it (see Fig. 1). The remaining space within the bottom $\frac{1}{2}$ in. of the sleeve was then carefully packed with plasticine to form a seal and the remainder of the mount filled with a cold curing resin. When the resin was set, the mount was

* Telephone Cables Ltd., Dagenham Dock, Essex.

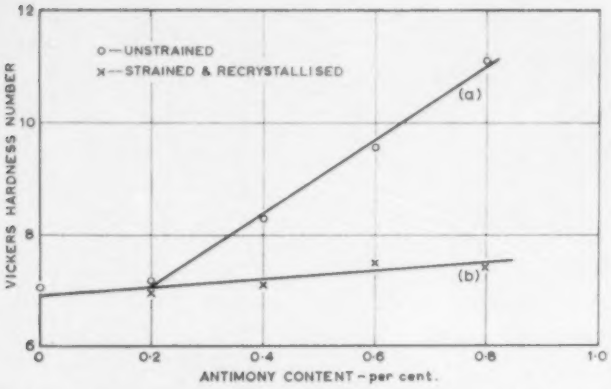

Fig. 2.—Corrected results of micro-hardness tests on aged lead-antimony alloys: (a) age-hardening curve; (b) equilibrium hardness curve.

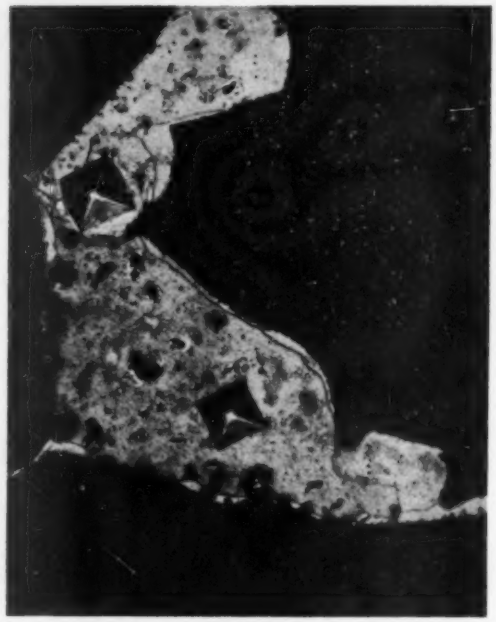

Fig. 3.—Micro-hardness indentations in recrystallised region of 0·8% antimony alloy, showing relative sizes of precipitate particles and indentations and the dispersion of the precipitate. ×500

lifted from the glass plate and the plasticine removed, leaving a composite specimen which could be ground and polished without difficulty, by virtue of the support afforded by the lead sleeve. The final etching reagent used prior to micro-hardness testing was that described by Worner and Worner[4], which contrasts areas containing continuous and discontinuous precipitation of antimony.

The micro-hardness testing was carried out in the areas of continuous precipitation in the unstrained specimens, and in the recrystallised areas containing discontinuous precipitate in the strained specimens. A number of indentations, made under a load of 1 g. applied for 15 seconds, were measured in each of these and also in the standard, pure lead specimens. The averages of the results obtained are given in Table I.

The identical standard lead specimens gave a range of hardness values with a standard deviation of 0·39 hardness units, equivalent to a coefficient of variation of 5·5%. This value indicated the extent to which the other hardness results might be in error for reasons associated with the difficulty in obtaining identical balance conditions in each case.

To carry out the correction procedure, it was first necessary to select a standard value for the hardness of the pure lead specimens, and the mean of the results obtained in the tests seemed an obvious choice. A multiplying factor was then calculated for each mount to produce a hardness for the standard lead specimen of 7·04 units, and this factor was used to correct the hardness values of the other specimens in the same mount. For the purposes of comparison with normal, macro-hardness tests, it should be noted that the Vickers diamond pyramid hardness of the pure lead specimen would be about 4·0 units for a 1 kg. load. The corrected results are given in Table II.

The reliability of these corrected hardness values can be assessed by plotting them against composition as in Fig. 2. It can be seen that the results lie substantially on two straight lines, one with a slight slope showing the moderate hardening effect of antimony in lead under equilibrium conditions, and the other with a more pronounced slope showing the effect of age hardening. These two lines intersect in the region of 0·2% antimony, supporting the results of earlier microscopical work that this is the limit of solid solubility of antimony in lead at room temperature.

The regions containing discontinuous precipitation in those alloys of over 0·2% antimony will all have matrices of this composition, and the slight increases in hardness will be due to greater amounts of precipitated antimony. Although these precipitated particles are, doubtless, considerably harder than the matrix, their hardening action is solely due to their ability to restrict slip, since, even in the 0·8% alloy, they constitute only about

TABLE I.—UNCORRECTED MICRO-HARDNESS VALUES OF LEAD-ANTIMONY ALLOYS
(Vickers diamond pyramid: 1 g. load for 15 sec.)

Antimony Content %	Hardness Number		
	Unstrained Specimen	Strained Specimen Recrystallised Area	Standard Lead
0·2	6·78	6·57	6·70
0·4	7·85	6·72	6·66
0·6	9·91		7·31
0·6		8·13	7·06
0·8	11·08		7·05
0·8		7·18	6·84
		Mean	7·04

TABLE II.—CORRECTED MICRO-HARDNESS VALUES OF LEAD-ANTIMONY ALLOYS
(Vickers diamond pyramid: 1 g. load for 15 sec.)

Correction Factor	Antimony Content %	Hardness Number		
		Unstrained Specimen	Strained Specimen Recrystallised Area	Standard Lead
1·051	0·2	7·13	6·91	7·04
1·058	0·4	8·29	7·09	,,
0·963	0·6	9·54		,,
0·919	0·6		7·47	,,
0·999	0·8	11·07		,,
1·029	0·8		7·39	,,

1·5% of the total volume of these regions, and neighbouring particles will be too far apart for their own hardness to play any substantial part in that of the total assembly. A parallel case which might be cited is the insignificant increase in the effort required to stir a Christmas pudding when a few sixpences are added. This point is further demonstrated by Fig. 3 which shows two micro-hardness impressions in an area containing discontinuous precipitate in the 0·8% antimony alloy. The dispersion and small size of the precipitate particles relative to the indentations can be readily appreciated.

Acknowledgment

The author wishes to thank Mr. A. F. Lampitt, managing director of Telephone Cables, Ltd., for permission to publish this paper.

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Textbooks and Teaching

(*Continued from page* 264)

never be outdated, and that we do need to consider our metallurgical courses, to see whether we have the text books to match them.

"The matter is urgent and important. Nationally the methods of technical education have just been reconsidered, and it has been decided that we need three grades of person, who, for want of better terms, are designated the craftsman, the technician and the technologist. The qualifications of this Institution are qualifications at the grade of technologist, and we are in the course of revising our requirements in a form which will serve the needs of the next decade. The three grades are primarily grades of temperament and capacity, but it is important to realise that no man is entirely a craftsman or entirely a technologist. I am a craftsman when I consider how I am to frame my sentence, but a technologist, scientist or philosopher when I consider what I want to say. No craftsman is so dull as not to be interested, at the proper level, in the whys and wherefores of his craft, and no scientist is so exalted as not to be grateful for a cookery book recipe when he needs it. Indeed I notice that the more distinguished a man is as a theoretician, the more cookery book minded he is when he comes to a job of practical work outside his speciality. It is therefore our interest to see that all three grades are properly served with good text books of their kind, and that distinguished quality of mind which is so important in arousing the will to study is evident in them all.

"The qualities required are different, because the people to whom they must appeal are different. There are four levels of scientific writing. The fountains of knowledge are the original papers, which, published by independent societies and subject to the discipline of open criticism, record the results of scientific experiment or technological enterprise. The second level is the critical review, made necessary by the multiplicity of original publications, whose chief function is to lead the enquirer to the relevant papers, and protect him from the irrelevant. Both these are the province of the independent scientific society, and professional people should support their activities and protect their independence by every possible means. The third level is the text book, which takes a range of subject matter either broad or narrow, and presents it with the best possible degree of correctness and balance, and the fourth is the primer which introduces a subject with emphasis on all that is basic and permanent. These are primarily the responsibility of the universities and technical colleges, but the professional society may properly take an interest in them.

"Text books at the professional level fail in one of their main purposes if they do not lead to the habit of consulting the primary sources, and consequently they must be able to develop curiosity, judgment, and appreciation of intellectual values and of intellectual pleasures. A great difficulty is to know at what distance behind current research they should follow, for if they are too close there is danger that they will lend authority to opinions that subsequently prove to be wrong, and if they are too distant they will be ousted by less sound treatises that seem to be more exciting. A degree of dogmatism is necessary, for even in the most advanced treatments the reader requires a clear lead, but dogmatism tends to generate a certain brutality, and is safe only in the hands of people of a sensitive and idealistic temperament.

"The characteristics of books at the technician level are thoroughness, attention to detail and awareness of the contemporary scene. The technician is generally the man who handles the job and he must know what he is doing, and why. He is making something, or providing a service, that is wanted now. The academic standard is not necessarily less than that of books at the professional level. On the contrary some of the most exhaustive and exacting treatments are to be found in books with the technician's approach. But the range is generally narrower, and the objective more restricted. These books are essentially for the people who delight in being experts. Nevertheless, everyone, no matter how wide his range of interests, must be expert at something if he is to be really useful. The metal physicist at some stage of his career must generally be an expert microscopist, and the theoretical physical chemist an expert vacuum technologist. Everyone therefore has need of books of this kind.

"The technician's text book can be hard, efficient and uncompromising. The primer offered to the young man straight from school, who is on trial to find out how far he can go, and to whom the subject he is attempting is very much on trial, is a more delicate instrument, for it requires understanding of the attainments and needs of the recipient, and the power to convince him of the worth of the work he is setting out to do. Most of all, it needs to be unfailingly exact in its selection and presentation of fundamentals, for we all learn best when we are

youngest, and what we learn then underlies everything that we do later.

" All these books, with the possible exception of the last, should preferably be written by younger men, although the co-operation of the younger man and the more experienced has sometimes been very successful. Their writing requires intellectual qualities of a very high order, and one of our main objectives should be to persuade those organisations that have the responsibility of recognising merit that it is work of equal or greater value than much of the ' original ' research upon which money is now so freely spent, and is equally deserving of being recognised by degrees and advancement. If we see ways of doing so usefully, we should be prepared to spend money on it and try to interest the brighter young men in the problem of producing books that will survive as standard text books for the period of their working lives.

" In saying this I do not wish to be understood to agree with those who have recently advocated that research and teaching should be separated, and certainly not with those who think that teaching is a function for men of spent powers or of moderate ability. Rather I think that research and teaching should go hand in hand, and that in every subject, and not only in technology, research to determine what should properly be taught, is a vital activity upon which the stability of a complex civilisation ultimately depends."

Physical Society Exhibition

(*Continued from page* 314)

Proportional Counter for Micro-Analyser

The proportional counter shown by Cambridge Instrument Co., Ltd., for use with the Microscan X-ray analyser is used for detecting the hard radiations from elements with the higher atomic numbers within the range of the Microscan and is interchangeable with a flow counter for soft radiations. It consists of a cylindrical gas-filled ionisation chamber with a central wire electrode 0·002 in. in diameter positioned along its axis and fixed to each end by an insulating glass-to-metal seal. X-rays enter the side of the cylinder through a beryllium window 0·005 in. thick and cause ionisation of the gas. If the electrode is at a suitable potential with respect to the cylinder, this ionisation is discharged and the electrons, diffusing to the central electrode, cause multiplication and produce a pulse. At a given potential the magnitude of this depends on the number of electrons (i.e. the number of ion pairs) formed by the X-ray quantum, and is therefore a measure of the quantum's energy or wavelength. Varying the potential of the wire electrode controls the multiplication and hence the pulse height.

The inside diameter of the counter is 1 in. and to make it function efficiently at the shorter wavelengths, the proportion of X-ray quanta absorbed in collision with the gas molecules over this distance must be high. For this reason a heavy gas is needed and xenon is used with a small amount of added ethyl formate to stabilise the gas multiplication. The gas mixture is introduced to the cylinder through one of the glass-to-metal seals before the counter is finally sealed. Airtight caps fitted with O-ring seals are screwed over each glass-to-metal seal to maintain atmospheric pressure around the ends of the wire electrode and to prevent corona discharge.

The counter works within the range 1,000–2,000 V.

Radiant Zone Heater

Somewhat unorthodox heating techniques appear to be the province of Electrothermal Engineering, Ltd., ranging from flexible furnaces for heating unusually shaped structures to the small radiant zone heater shown at the Physical Society Exhibition. In this type of equipment, highly concentrated heating is obtained by focusing the heat sources optically upon the section or object to be heated. As the heat is transferred by radiation there is no danger of contamination, and the heating element being remote allows the unit to be placed over evacuated tubes.

This type of heater has so far been applied to vacuum zone refining, to soldering, to sintering of alloys, and to sample heating during physical examination by magnetic, microscopic and X-ray diffraction techniques. Temperatures in excess of 1,200° C. have been obtained on the inside of a $\frac{1}{2}$ in. diameter crucible in air.

Davy-United Instruments for Russia

SPECIAL nucleonic instruments, developed in Britain, will soon be helping the spread of automation in Russia's steel industry. Davy and United Instruments, Ltd., of Sheffield, announce that they have signed a contract with Stankoimport of Moscow, for the supply of eight transmission gamma ray thickness gauges to be installed in Russian steel mills. These gauges use a radioactive isotope as the measuring medium and are capable of continuous measurement to extremely fine limits of accuracy, on anything from white-hot steel plate to cold strip, without touching the material being rolled.

One of the gauges will be used for measuring hot steel plate between 3·75 mm. and 50 mm. thick. Another will be used on a hot strip mill for measuring hot rolled strip between 1·5 mm. and 12·5 mm. thick. The remaining six gauges will all be installed on cold strip mills to measure strip between 1·5 mm. and 12·5 mm. thick.

The value of the contract exceeds £90,000 ; it has been negotiated through the Trade Delegation of the U.S.S.R. in the United Kingdom, and delivery will take place during the first quarter of 1962. As is customary with Davy-United radiation instruments of this type, the radioactive source and detection device will be supplied by Isotope Developments, Ltd., of Reading.

Davy and United Instruments, Ltd., a member of the Davy-Ashmore group, specialise in automatic instrumentation for steelworks processing, and their gaugemeter system of automatic gauge control, which has already been installed in strip mills in several countries overseas, has been on show to the Russians on the stand of the British Iron and Steel Federation at the Moscow Fair.

THE office of the Lead Development Association, is now at 34 Berkeley Square, London, W.1. Telephone : GROsvenor 8422 ; Telegraphic Address : Leadevep, Wesdo, London.

APEX

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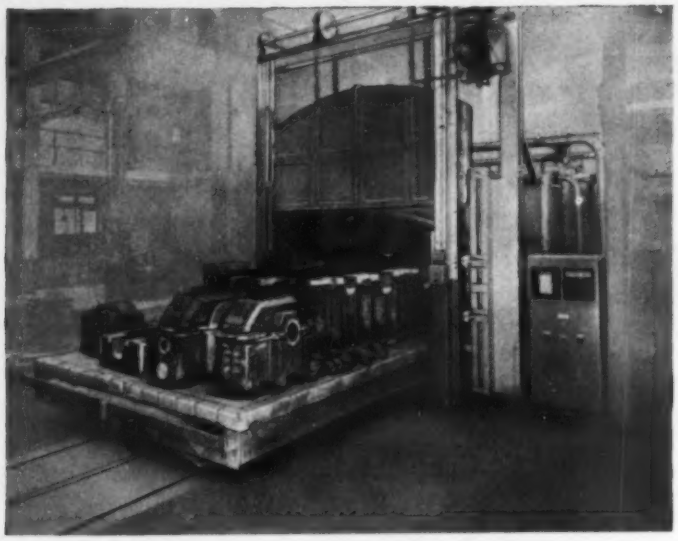

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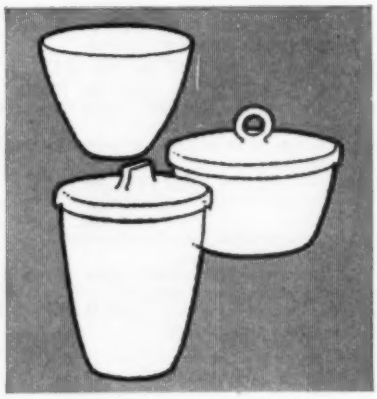

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for the Welding Department of the Research and Development Division. This post will provide an opportunity for interesting work associated with welded fabrications, materials and weld testing, and the development of welding techniques and equipment. Applicants should have a degree or equivalent professional qualifications, together with experience in non-ferrous and knowledge of ferrous materials. Ref.: 27/61

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for the Heavy Equipment Division. Applicants should be over 25, with at least HNC, and must have experience in weld design in ferrous and non-ferrous materials, and a basic knowledge of the associated welding problems. They must be familiar with modern welding techniques and be able to advise upon and co-ordinate the work of research, design, and production teams. Ref.: 29/61.

The location of both these jobs is Darlington, which is a pleasant town surrounded by most attractive countryside.

Send detailed applications to **The Staff Officer, Whessoe Limited, Darlington,** quoting the reference and mentioning this paper.

SITUATIONS VACANT—*continued*

GLACIER METAL CO. LTD.

KIRKSTYLE, KILMARNOCK, AYRSHIRE

invite applications for the position of

PROCESS METALLURGIST

The successful candidate will carry out investigations into the operating conditions of certain processes associated with the production of sintered materials. The desire is to establish control procedures aimed at achieving an optimum balance between high technical standards and general economic efficiency.

Although his work, which is mainly concerned with powder plants, sintering furnaces, rolling mills, and ancillary equipment, lies in a production department, technical services and similar facilities will be available to him.

Applicants should be 22–35 years of age and have experience of industrial research, quality control or direct production experience in relevant fields, extending over a minimum period of 2 years.

A good H.N.C. in metallurgy would be the minimum acceptable technical qualification.

A starting salary in the range £14–£18 per week is envisaged but a higher initial salary might be offered to a candidate with exceptional qualifications and experience.

Brief details of age, qualifications, experience and present salary should be sent to Personnel Dept., quoting Ref. No. 3/MU/5/47/.

ENGELHARD INDUSTRIES LTD.

have an attractive opening for a young

METALLOGRAPHER

with considerable initiative and an aptitude for experimental work. The successful candidate would have ample scope to develop new techniques and would be expected to take charge of a newly equipped section in the company's metallurgical laboratories situated at Chessington.

There is also a vacancy for an assistant interested in development work on the precious metals and the solving of works' problems under the direction of the project metallurgist.

Applicants for the first post must have H.N.C. or equivalent, and it would also be desirable for the second position.

They should be in their early or mid-twenties. A competitive salary would be paid according to experience and qualifications.

Please write to : The Personnel Officer, Engelhard Industries, Ltd., 154–170, Vauxhall Street, London, S.E.11.

SENIOR METALLURGIST

A vacancy exists for a Senior Metallurgist, aged between 25 and 35, qualified to A.I.M. level and possessing the appropriate industrial experience.

The successful applicant will be required to work on production problems involving a wide range of ferrous and non-ferrous materials as used in the telecommunications industry. A knowledge of heat treatments and fabrication methods is essential and some experience in resistance welding desirable.

Write in confidence to the Personnel Manager,

STANDARD TELEPHONES AND CABLES LIMITED

Oakleigh Road, New Southgate, N.11

SITUATIONS VACANT—*continued*

ENGLISH ELECTRIC VALVE CO. LTD.

Chelmsford **Essex**

METALLURGIST

The company specialises in the manufacture of transmitter valves and tubes for radio, radar television and industrial electronics.

Many problems arise in non-ferrous metallurgy in the processes and materials used in these valves and tubes, and a qualified and experienced metallurgist is required for their investigation.

Age range 30–40, an Honours degree in metallurgy, non-ferrous metallurgy and vacuum technique experience, are the principal qualifications required.

We should also be pleased to hear from any applicant whose experience has been mainly in non-ferrous metallurgy in the valve industry but who does not necessarily have all the qualifications listed.

Applications should be submitted to: Group Personnel Services, English Electric House, Strand, London, W.C.2, quoting Ref. 1514L.

FUELS CHEMIST

FOSTER WHEELER, LTD., invite applications from senior Fuels Chemists, of degree or equivalent standard, for the establishment of a fuels section in our laboratories at Egham, Surrey.

The section will be engaged on the full analysis and evaluation of both solid and liquid fuels in support of the power station and marine boiler programmes of the company. Work on the characteristics of pulverized coal will be of particular importance and the section will also be responsible for ash and combustion deposit evaluations, and for consultation on general problems of combustion.

It will be the responsibility of the successful applicant to establish the facilities necessary for carrying out these commitments, and some previous experience of fuel-testing techniques is therefore essential.

A good salary, commensurate with the responsibility involved, will be paid and the company also operates a pension and bonus scheme.

Please write fully, quoting Ref. 15/AB, to:

The Office Manager,
FOSTER WHEELER, LTD.,
Foster Wheeler House, Chapel Street, London, N.W.1.

ASSISTANT METALLURGIST of degree or A.I.M. standard with a sound practical knowledge of metallography required for general metallurgical laboratory concerned with a wide range of materials and processes used in the manufacture of aircraft fuel systems. Applicants should have previous experience in the investigation of failures which will form a large part of the work and should be able to work on own initiative.

Please apply in writing to the Personnel Manager, Joseph Lucas, Ltd., Shaftmoor Lane, Hall Green, Birmingham, 28.

ASSISTANT ANALYTICAL CHEMIST

REQUIRED for laboratory engaged in metallurgical and inorganic analysis. Applicants should be of O.N.C. or similar standard. A knowledge of mineral or slag analysis would be an advantage.

Applications should be addressed to:
Chief Metallurgist,
LINCOLN ELECTRIC CO., LTD.,
Welwyn Garden City, Hertfordshire.

please mention
Metallurgia
when replying to
advertisements

SITUATIONS VACANT—*continued*

METALLURGISTS
required by the
UNITED KINGDOM ATOMIC ENERGY AUTHORITY, PRODUCTION GROUP, SPRINGFIELDS WORKS, SALWICK, PRESTON, LANCASHIRE

POST A in the CHEMICAL AND METALLURGICAL SERVICES DEPARTMENT, involves work in the metallographic laboratories providing a service to a works producing fuel elements for nuclear reactors. Duties will involve examination and investigation connected with production of elements and plant constructional materials, and will include development of metallographic examination techniques. A wide range of modern equipment has recently been installed in the laboratories.

Experience in a metallographic laboratory is desirable, and some practical knowledge of magnesium alloys and the newer metals, although not essential, would be an advantage. (Ref. 8F.86/).

POST B in the TECHNICAL DEPARTMENT (METALLURGICAL SECTION), will involve technical control of fuel element manufacturing, for which knowledge of modern vacuum melting and casting techniques, heat treatment and welding of the newer metals, would be an advantage. (Ref. 8F.83/).

An honours degree in Metallurgy, or Associateship of the Institution of Metallurgists, is essential for both appointments.

Salary for both posts: £1,005 (at age 25)—£1,350 (at age 34 or over)—£1,535.

Contributory Superannuation. Housing Assistance Schemes.

Send postcard for application form, quoting appropriate reference, to Works Secretary at above address.

Closing date: 30th June, 1961.

WHESSOE LIMITED
RESEARCH AND DEVELOPMENT DIVISION

invite applications from Qualified Metallurgists for a vacancy in the Welding Department. The post provides an opportunity for interesting work associated with welded fabrications, materials and weld testing, and the development of welding techniques and equipment.

Applicants should have a degree or equivalent professional qualifications, together with experience in non-ferrous and knowledge of ferrous materials.

The location is in Darlington, which is a pleasant town surrounded by a most attractive countryside.

Apply to the Staff Officer, Whessoe, Ltd., Darlington, quoting reference 27/61, and mentioning this paper.

THE MANCHESTER COLLEGE OF SCIENCE AND TECHNOLOGY
(Faculty of Technology in the University of Manchester)
Appointment of
LECTURER IN METALLURGY

Applications are invited for the post of Lecturer in Metallurgy with the title and status of Lecturer in the University of Manchester. Salary according to qualifications in the scale £1,050 to £1,850. Superannuation under the F.S.S.U. Family allowances. Candidates must be prepared to undertake or supervise research, for which there are excellent facilities.

Conditions of appointment and application form may be obtained from the Registrar, The Manchester College of Science and Technology, Manchester, 1, to whom applications must be returned by *Saturday, 24th June*, 1961.

CLASSIFIED ADVERTISEMENTS

SITUATIONS VACANT—*continued*

FURNACE DRAUGHTSMAN

A vacancy exists for a Draughtsman with experience of gas, oil and electric furnaces, to work in the drawing office of our works at Bletchley, Bucks. The company is small but progressive, and the successful applicant must be prepared to tackle a wide variety of drawing office tasks. Salary will depend upon age and experience. The company operates pension and profit-sharing schemes. Promotion prospects are excellent. Housing is available to anyone now living in London.

Please apply giving full details to the Secretary, Kasenit, Ltd., 7, Holyrood Street, S.E.1.

RESEARCH ASSISTANT for metallographic laboratory required. Knowledge of special techniques, particularly electron microscopy, an advantage. Salary according to qualification and experience. Write: Research Supt., British Non-Ferrous Metals Research Association, Euston Street, London, N.W.1.

SITUATIONS WANTED

METALLURGIST. L.I.M. Age 33. Extensive experience in arc melting, drop forging and electrodeposition, seeks position in area Doncaster, Scunthorpe, Lincoln. Box No. MH.111, METALLURGIA, 31, King Street West, Manchester, 3.

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PLANT FOR SALE. A complete high frequency melting plant, of 2 only 10 cwt. furnace bodies, 150 kVA. Apply Box No. MH110, METALLURGIA, 31, King Street West, Manchester, 3.

M.P.A. FOR SALE

FOR Sale one "Holophot" Metallurgical Microscope by Watsons of London, date of manufacture approximately 1945, reconditioned by makers, May 1961.

The equipment includes: Microscope with three objectives, two pairs of eyepieces, one macro lens, ¼-plate camera and illuminating system. Maker's valuation £200. Enquiries to Box MH.112, "Metallurgia," 31 King Street West, Manchester 3.

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N.H.P. Mounting Plastic, a cold-curing acrylic resin, permits the rapid mounting of metallographic specimens without the aid of heat or pressure.

It calls for the minimum of equipment and skilled attention and yet gives a close, tight mount, capable of a high degree of edge preparation.

Used routinely by many leading manufacturers. Full details on request to the makers: NORTH HILL PLASTICS, LTD., MANLEY COURT, LONDON, N.16.

MISCELLANEOUS

NOTICE

Applications for the exploitation of Hofrat En Nahas Copper Mine are invited by the Sudan Government. The explored area proved to contain more than 10 million tons of ore with average copper content of 2·78. More details can be obtained from the Sudan Embassy, 3, Cleveland Row, London, S.W.1.

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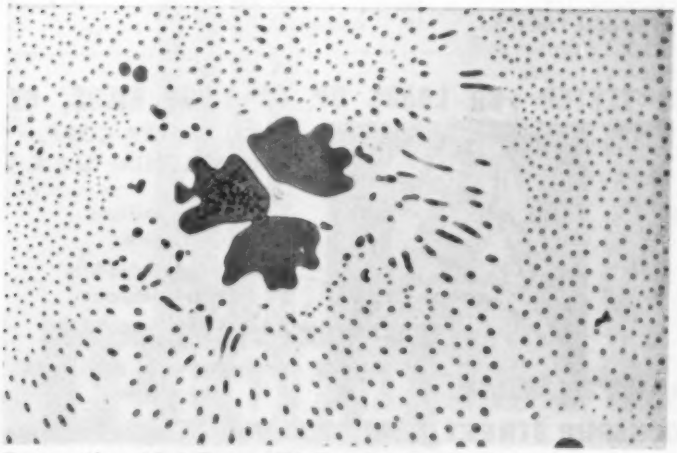

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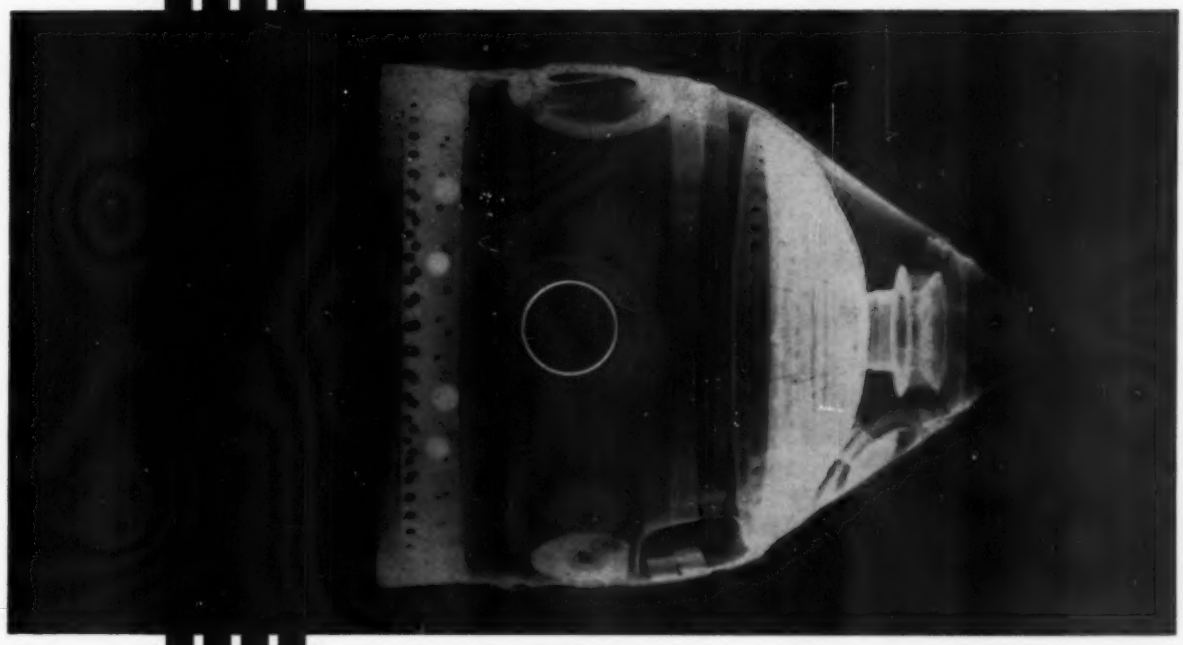
For radiographing assemblies, castings and welded seams



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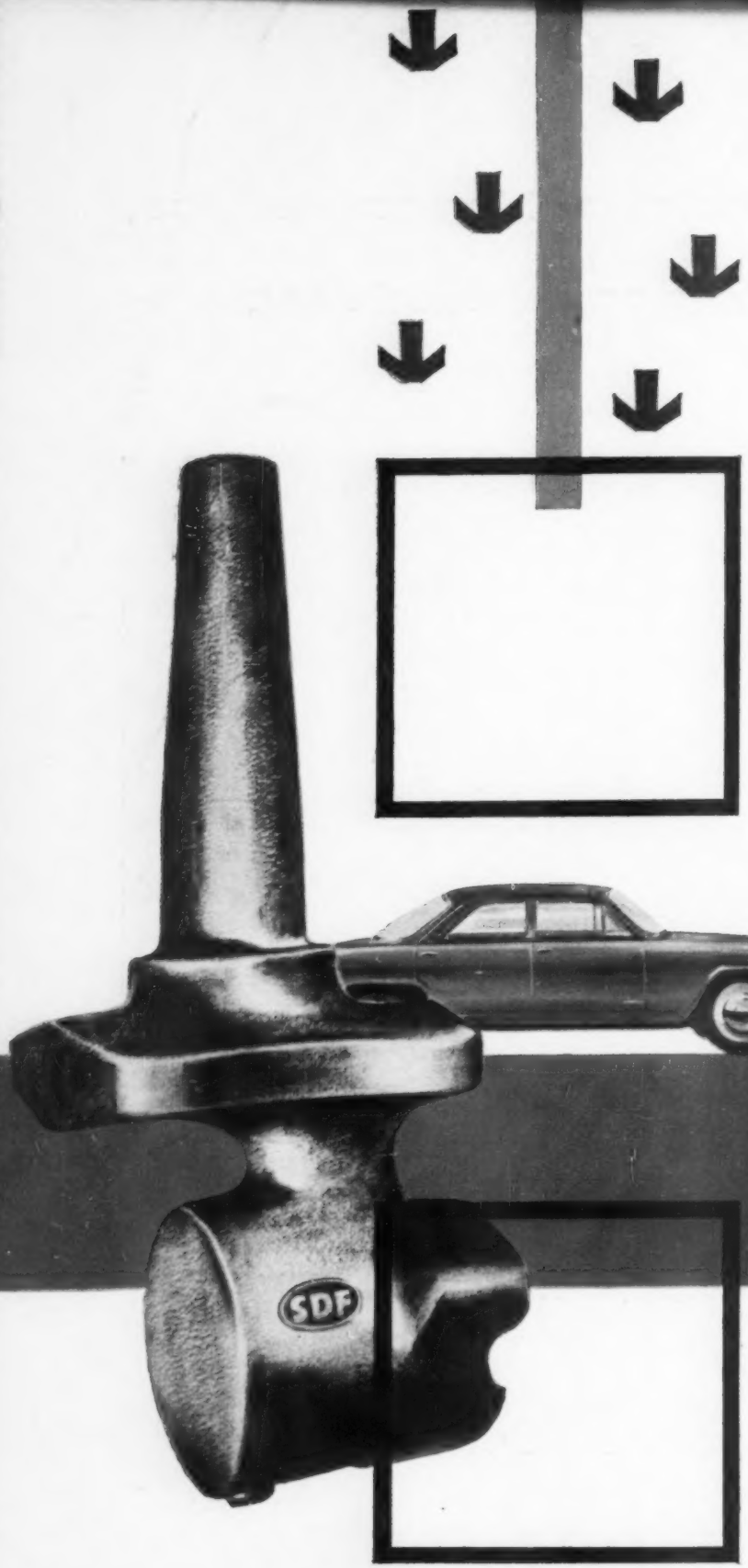

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